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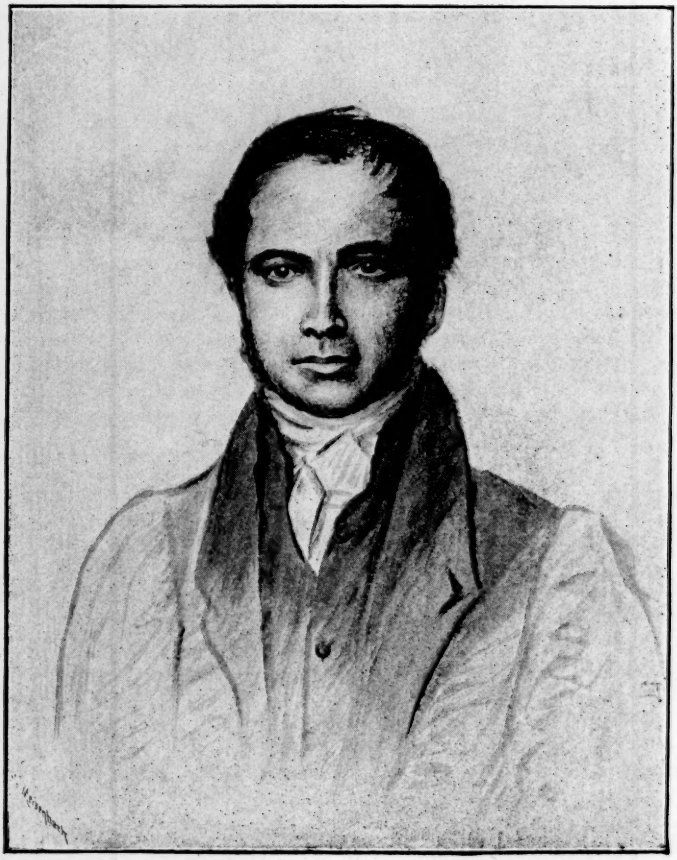

Sam Woodward

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VIII.

No. I.—JANUARY, 1891.

ORIGINAL ARTICLES.

I.—A Geologist of a Century Ago:

Samuel Woodward of Norwich, Antiquary and Geologist.[1]

(With a Portrait.)

GEOLOGISTS are so accustomed to deal with vast periods of time, that a century may be deemed by them as equivalent to the moment-measure of the dial, or the sand-grains of the hour-glass. Nevertheless a century, in human affairs, especially that just expiring, has for us a vastly wider significance, and although its passage may not have seen the birth, it has witnessed all the growth and development of Geological science, and a large proportion of that of her sisters also. It cannot be without interest, therefore, briefly to record in these pages the name of one who, although born a hundred years ago, with but scanty opportunities either of position or education to assist him, yet by sheer force of energy and perseverance, and attracted by a strong love of Nature, became a geologist of no mean merit, and left behind him a name honoured by those who knew him, and a record of work accomplished, worthy to fill a much longer life.

Samuel Woodward was born at Norwich, on the 3rd October, 1790. His grandfather, Simon Woodward, came from London to settle in Norwich, where he married and left two children, the younger of whom, William, born in 1762, married, in 1789, to Elizabeth Springall, and died in 1795, at the early age of 33 years. He left a widow and two children, the elder of whom was Samuel Woodward, the subject of the present Memoir. His father died before he was five years old, and after attending a day-school for a short time, he was placed under the care of a relative who was a shawl-weaver, then one of the staple manufactures of Norwich. So desirous was the boy to learn that he devoted every spare moment to study, and read with eagerness every book which came within his reach. At ten years of age we find him singing, as a

[1] Those who are interested in the story of a Norwich boy who became a geologist may read the fuller account, of which this is but an abstract, in the Transactions of the Norfolk and Norwich Naturalists' Society, vol. ii. pp. 563–593, 1879, by Horace B. Woodward, F.G.S. (grandson of Samuel Woodward), and author of the "Geology of England and Wales," one of the best text-books ever written. The portrait is reproduced by permission from an original sketch, in Indian ink, in the possession of his daughter, Mrs. T. G. Bayfield of Norwich, drawn from life by his eldest son, B. B. Woodward.—Edit. Geol. Mag.

chorister, on Sundays, in St. George's Colegate, the church of the parish in which he lived with his mother. Here he was introduced to Mr. Alderman Herring, a wealthy manufacturer, and at one time Mayor of Norwich, who kindly took the lad into his warehouse, and having first placed him in a school for a short time, he afterwards bound him apprentice to his own business, that of weaving Camlets and Bombazines. Here he gradually rose to a position of trust and responsibility; nor did he, during this period of twelve years, neglect any opportunity of improving his mind, eagerly availing himself of the kind permission given him by Mr. Herring to use his library for study whenever he had leisure to do so. His pursuits had already assumed the form they retained in later life. He collected and cultivated flowers, and his room was adorned with curios and shells which he bought at the old-curiosity shops in the city.

One of the first geological puzzles he endeavoured to solve was a mass of flint containing *Ananchytes*, which he had noticed on a cottage mantel-piece, where it was kept, well black-leaded, as an ornament. And one of the books which first excited his attention, and perhaps directed it to antiquarian and geological studies, was Verstegan's "Restitution of Decayed Intelligence, in Antiquities concerning the most noble and renowned English Nation," a curious work, of which the first edition was published in 1605, and in which the former connection between England and France was then advocated.

He not only used every opportunity of adding to his own store of knowledge, but was ready to help others, for he himself taught in both an evening and a Sunday school. It was whilst thus engaged that he became acquainted with Joseph John Gurney, who, throughout his life, proved a true friend to him.

In 1812 Mr. Herring gave up his manufactory owing to the general depression of business, but in 1814 Samuel Woodward obtained a clerkship in the Norwich Union Fire Office, which he held for six years, when he entered the Banking-house of Messrs. Gurneys' & Co., where he remained until his death.

In 1815 Samuel Woodward married Elizabeth, daughter of Bernard Bolingbroke, Esq., of East Dereham, Norfolk, and niece of Nathaniel Bolingbroke, Esq., formerly Mayor of Norwich, and of Sir John Yallop, Sheriff of that city. This union resulted in a family of six sons and three daughters; but one son and one daughter died in their infancy.

After 1820, he was brought prominently under the notice of Hudson Gurney, Esq., M.P., of Keswick, and Dawson Turner, Esq., of Yarmouth, both Fellows of the Royal Society, and partners in Gurney's Bank. It was to their friendly aid and encouragement that he largely owed the opportunities he enjoyed for the prosecution of his favourite studies, and also the success which attended his labours. To them he was particularly indebted for the loan of books, and for aid in his publications.

The works of Parkinson, William Smith, and, later on, those of

Conybeare and Phillips, became his text-books; while the writings of Richard Taylor gave an impetus to his local researches. Taylor's earliest paper was published in 1822,[1] and in the following year Samuel Woodward made his first geological tour of the coast, but without obtaining any specimens of fossil bones. In 1824 Mr. Robert Lacy sent him two molars of Elephant from Mundesley, and soon after he made another excursion from Yarmouth to Cromer along the beach, and obtained some good specimens; and might, he says, have obtained some very large and fine bones, but for the difficulty of conveyance.

From this year and up to the time of his death he maintained a considerable correspondence with many of the leading naturalists and geologists of the day. The letters he received, together with many miscellaneous notes and memoranda, are preserved in eleven quarto volumes, now in the possession of his youngest son, Dr. Henry Woodward, F.R.S. During this period of fourteen years he seems to have kept every scientific letter he received, and it must be remembered that in those days letter-writing was, as a rule, far more elaborate and careful than it is now. Many of these letters are only of value as autographs, and merely relate to inquiries as to coins, rings, seals, merchants-marks, ancient buildings, and other antiquarian matters mostly of local interest. Others bear upon geological topics: amongst them we find letters from William Bean (of Scarboro'), C. W. Peach, R. C. Taylor, Hudson Gurney, Dawson Turner, the Rev. James Layton (of Catfield); Thomas Amyot (Treasurer of the Society of Antiquaries), J. W. Robberds, Miss Etheldred Benett,[2] Goddard Johnson, H. Denny (of Leeds), Daniel Stock (of Bungay), Dr. Buckland, Prof. Sedgwick, Dr. Mantell, G. B. Baker (of Bungay), Dr. Charles König (British Museum), Sir R. I. Murchison, Prof. John Phillips, Dr. James Mitchell, Wm. Gilbertson (of Preston), the Rev. Thomas Image (of Whepstead), the Rev. George Munford, the Rev. W. Foulger. There are also short notes from Fitton, De la Beche, Lyell, Agassiz, Sir Philip Egerton, Elizabeth Fry, Harriet Martineau, and Charles Waterton.

Samuel Woodward's first letter to Mr. Caleb Rose, F.G.S., of Swaffham, was written in May, 1826, and from that date there was an uninterrupted correspondence, mostly on geological topics, until the death of the former in 1838. The enthusiasm of the two friends seems to have been very great; every discovery of a new fossil was at once communicated, while books and specimens were borrowed and exchanged, in a way that speaks well for the prosecution of science in those days.

In 1824 he made his first communication to one of the learned Societies of London. It consisted of a series of maps and plans of Ancient Norfolk, which he submitted to the Society of Antiquaries through Mr. Hudson Gurney. One of these maps illustrated the Roman period, showing the several stations and roads constructed

[1] "Fossil Bones on the Coast of East Norfolk," Phil. Mag. vol. lx. p. 132, 1822.

[2] Well known to geologists as authoress of "A Catalogue of the Organic Remains of the County of Wilts," 1831; (of Norton House Warminster, Wilts).

by the Romans; another pictured the great estuary which it was considered had spread itself as far as *Venta Icenorum* (Norwich) before the sands on which Yarmouth was built were left uncovered by the sea. This latter map was based upon the ancient 'Hutch Map,' belonging to the Corporation of Yarmouth, with, however, many inaccuracies as to places and distances corrected.

In 1825 he had already nearly completed two works in MS., one entitled "Sketch of the Norwich Crag Deposit, with a Descriptive Catalogue of its Fossils," a quarto volume containing twenty plates with outline figures of the species; the other, entitled, "Remarks on the Geology of the County of Norfolk," 4to. illustrated with coloured figures of the fossils and coloured sections of the strata. Both works, however, were commenced and carried out on a plan far too ambitious and expensive for publication. The projected "Geology of Norfolk" was to comprise 24 plates, and nearly 1000 figures; he had already drawn about 300, and others were subsequently added; these remain as he left them. The substance of his observations, and figures of many of the species were, however, published in his "Geology of Norfolk," in 1833. The original drawings of fossils are extremely accurate and very carefully executed and bespeak considerable native talent. In 1826 he was elected a member of the Committee of the Norfolk and Norwich Museum (established in 1824), an office which he held at intervals during the subsequent years of his life. In 1827 he exhibited before the Society of Antiquaries, in London, some antiquities found at Coltishall, which he conjectured to have been a landing-place to the Romans when navigating the River Bure on their way to Bampton or Burgh-by-Aylsham. Later in the year he was engaged with Mr. W. C. Ewing, in exploring the Barrows at Eaton Heath. The Bronze Celts and a perfect metal mould obtained there, were exhibited at the Society of Antiquaries, Dec. 6, 1827 (see Archæologia, vol. xxii. p. 424, 1829). On the 5th Feb. 1828, he was elected an Honorary Member of the Yorkshire Philosophical Society, at the suggestion of John Phillips, then Curator of the York Museum, with whom he frequently corresponded.

In 1828, in a letter to Dr. Fitton, F.R.S., President of the Geological Society of London (read 2nd January, 1829), he records the occurrence of Crag at Cromer, and westward at Coltishall, and around Norwich. To the eastward, instead of marine shells, he noticed that there occurred a layer of ligneous and mammalian remains reposing on the Chalk. In this, immense numbers of bones and teeth of the Elephant, Horse, Deer, etc., mingled with trunks, branches, and leaves of trees, had been found, extending even to the distance of twenty miles out to sea, and on the Knoll sands, etc. (Proc. Geol. Soc. 1829, vol. i. p. 93). In 1829, he communicated a short sketch of the geology of the county to the "Norfolk Tour," in which he states that in what was subsequently termed the "Forest Bed" there are found a surprising number of vegetable and animal remains, as trunks, branches, leaves, and stumps of trees (*in situ*), etc. He had two years previously (1827) recorded that

in his own collection from the coast were remains of Elephant, Rhinoceros, Hippopotamus, Horse, Bos, Irish Deer, and three other species of Deer.[1] Many of these were obtained from the oyster-bank off Hasboro', which he regarded as an extension of the blue clay of the cliff. He also observed that "the antlers of the deer are broken into fragments of from six to eight inches in length, and three-fourths of them had been shed, indicating that they were at present not far removed from their original locality, and appeared to confirm the tradition that this part of the sea, called 'the Holmes,' was originally a forest."

In a second communication to Dr. Fitton (23rd March, 1829), he pointed out that "Wherever a section has been made of the Crag of Norwich, with one exception, there has been found a layer of nodular flints from twelve to eighteen inches in thickness reposing on the Chalk. Reasoning from analogy he concluded that the Chalk in these instances had been subject to the action of currents of water previous to the deposition of the (Crag) shells; as the appearance of the flints perfectly agrees with the like phenomena going on at Foulness Point, Cromer, and at Trimmingham Beach, on our coast; . . . . The Chalk under these flints is perforated as if by *Pholades*." These notes, although not published at the time, appeared later on in the "Geology of Norfolk."

In April, 1829, he sent to Mr. Amyot some "Fragments illustrating the History of Norwich Castle;" and in May, some "Observations on the Round Towers of Norfolk," for the Society of Antiquaries. At the request of Mr. Daniel Gurney, he directed his attention, in 1825, to the collecting and publishing of Merchants' Marks, and later on he exhibited six examples referred to dates between 1409 and 1608, which he had drawn on stone ready for publication.

For some time past his "Synoptical Table of British Organic Remains" had been in preparation, entailing much research and correspondence; it appeared on 1st July, 1830, the list of subscribers numbering 155. This work, naturally, has now been out of date long ago, having been superseded in 1843 by the "Catalogue of British Fossils," by Professor Morris, the second edition of which appeared in 1854, now 36 years since. Happily the Vertebrata have been brought up to date by Messrs. Arthur Smith Woodward and C. Davies Sherborn, but the Invertebrata have only been partially listed in separate works, so that much remains to be done in order to complete our Catalogue of British Fossils.

In 1832, Samuel Woodward visited Mr. Hudson Gurney in London, and went the round of the principal learned Societies with him; making the personal acquaintance of a number of eminent geologists and antiquaries whom he had previously known by correspondence. He also attended a conversazione at Mr. (afterwards Sir Roderick) Murchison's house, where he met Dr. Buckland and Mr. (afterwards Sir Charles) Lyell, and others.

The year 1833 saw the publication, on the 1st of May, of his "Outlines of the Geology of Norfolk," one of the first works

[1] See Rev. J. Layton, Edinb. Journ. of Science, vol. vi. p. 199.

describing the geology of any English county, and one which in its plan and scope has not at present been superseded. Much necessarily requires revision in the classification of both the strata and their included fossils; but the work has retained its place as a standard book of reference for Norfolk. He attended the meeting of the British Association at Cambridge in 1833, in company with his friend Mr. Caleb Rose, of Swaffham, but they do not appear to have been much gratified with their visit; for, as his friend afterwards remarked in a letter, "authorities were ponderous," and we were only "insignificant labourers."

In this year Professor Sedgwick was appointed a Canon of Norwich Cathedral, and his advent was indeed a happiness to the Norfolk geologist. Dr. Mantell, writing from Brighton (December 14th, 1834), says: "Believe me you are most fortunate to have such a man near you; it will more than compensate for your distance from all the other savants in England. I think Mr. Sedgwick by far the most talented and splendid man we can boast of. I only wish we had a Cathedral here, and he had a stall in it."

During the Professor's residence in Norwich, they not unfrequently met, Sedgwick often inviting Woodward to the Close, and coming occasionally to spend an evening at Grove Cottage, to look over the treasures in his geological collection.

In February, 1835, he delivered a lecture on "The Antediluvian Topography of Norfolk" at an evening conversazione of the Norfolk and Norwich Museum.

About this period his health seems to have been very feeble; he was suffering from a most trying complaint, diabetes. At times he had to relinquish his duties at the Bank, and seek in travel and change of scene, a temporary alleviation from his indisposition. Thus, on the 13th July, 1835, he went by packet to Yarmouth, and thence to Hull, where he inspected the Hull Natural History Museum with Mr. W. H. Dykes, and Mr. John Edward Lee, the Curator of the Museum. He next proceeded to Beverley, and afterwards to Scarborough, where he met Mr. W. Bean, Dr. William Smith, and Mr. Williamson, and was shown the geology of the coast by William Smith. Thence to York to visit John Phillips and the York Museum; afterwards to Leeds, to the Museum and to visit Mr. H. Denny. Then on to Preston to stay with Mr. Gilbertson, the well-known collector of Mountain Limestone fossils.[1] Later on he returned viâ Liverpool, and made his first railway journey from that city to Manchester, thence to Nottingham and so through Derbyshire by Buxton and Matlock to Derby and back to Nottingham, then on to Newark and so home viâ Sleaford, Lynn, and Dereham to Norwich, a truly formidable journey in those days.

In 1836 we find him again in London, seeking health, though mostly visiting amongst friends and attending the meetings of scientific societies.

In September, the Marquis of Northampton, who was much interested in geology, visited him at Grove Cottage, Lakenham, in

[1] Whose collection, like William Smith's, is now preserved in the British Museum (Natural History).

order to see his collections; also Mr. Joseph Prestwich, jun. (afterwards Professor Prestwich, F.R.S.) who, paid his first visit to the Thorpe Crag-pits under Mr. Woodward's guidance, and there obtained a fine molar of *Elephas meridionalis*, now in the Norwich Museum.

Although his bodily powers failed him, his mental energies never ceased to display their activity, and even at the last he occupied himself with numerous archæological subjects, and with the preparation of a new work, "Theoretical View of the Geology of the Norfolk Coast," a MS. which was never published.

He was also engaged in the preparation of his "History and Antiquities of Norwich Castle," edited, after his death by his eldest son, B. B. Woodward, F.S.A., in 1847; and in gathering materials for the "Norfolk Topographer's Manual," revised, augmented, and edited by W. C. Ewing, and published in 1842. Nothing could exceed the sympathy and kindness shown to Mr. Woodward during his last illness by all his friends, but his malady baffled medical skill, and he died on the 14th January, 1838, in his 48th year.

Thus ended a life of devotion to science, a life whose published works form but a partial memorial of the indefatigable industry of their author. "I believe," writes Prof. Sedgwick, "it is not too much to say that his life has been cut short by his devotion to science, and by his continuing (after the laborious duties of the day) to spend hours in study, which ought to have been given to rest." "His memory," writes his eldest son, "remains an object of reverence to his children, whose paths, by his patience and toil, have been made so easy and pleasant compared with his own, and of unfeigned respect to all who were acquainted with his character and his acquirements."

LIST OF WORKS BY SAMUEL WOODWARD OF NORWICH.

1829.—1. Geology of Norfolk. In "A General History of the County of Norfolk intended to convey all the Information of a Norfolk Tour." [By J. Chambers.] 2 vols. 8vo. 1829.

2. A Letter [to Dr. Fitton] respecting some remarkable fossil remains found near Cromer, in Norfolk. [Read Jan. 2nd.] Proc. Geol. Soc. vol. i. pp. 93, 94.

3. Musical Snails. Mag. Nat. Hist. vol. ii. p. 244.

4. [Notes on some Antiquities found in Norfolk.] Archæologia, vol. xxii. pp. 422–424.

1830.—5. On the Hydra, or Freshwater Polypus. Mag. Nat. Hist. vol. iii. p. 348.

6. A Synoptical Table of British Organic Remains: in which all the edited British Fossils are systematically and stratigraphically arranged in accordance with the views of the Geologists of the present day; and a reference given to their localities, strata, and engraved figures. 8vo. and 4to. London and Norwich.

1831.—7. Observations on the Round Church Towers of Norfolk; and on the materials employed in constructing the early religious buildings in that County. [Read May, 1829.] Archæologia, vol. xxiii. pp. 7–9.

8. A Descriptive Outline of the Roman Remains in Norfolk, accompanied by a Map of the County. [Read Dec. 1830.] *Ibid.* pp. 358–373.

9. A Copy of an Ancient Plan of the Chalk Vaults near St. Giles' Gates, Norwich: made by John Bond, 1571; exhibited, with notes, by Mr. Samuel Woodward. *Ibid.* pp. 411–412.

10. Natural History Collection. Mag. Nat. Hist. vol. iv. p. 177.

11. Luminosity of the Sea. *Ibid.* p. 284.

12. Ætites or Eagle Stones. *Ibid.* p. 468.

1832.—13. *Trichiosoma lucorum*, the Pupa and Imago of, a Habitat of, and the destruction of by one of the Ichneumonidæ. Mag. Nat. Hist. vol. v. pp. 85, 86.
14. Luminousness of the Sea. *Ibid.* vol. v. pp. 302, 303.
15. Origin of the Crag Stratum of Norfolk. *Ibid.* vol. v. pp. 544, 545.
16. Sir John Byerley's Theory of verifying Dates by calculations on the Precession of the Equinoxes. *Ibid.* vol. v. p. 761.
1833.—17. An Outline of the Geology of Norfolk. 4to. and 8vo. Norwich.
18. The Natterjack in Norwich. Mag. Nat. Hist. vol vi. p. 457.
19. Remarkable Meteor seen from Norwich, Dec. 19th, 1832. *Ibid.* p. 463. [Also Letter in 'East Anglian,' 1832, on this subject.]
1834.—20. Drawing of Two Steelyard Weights, one of which was found at Catton; exhibited by Mr. Samuel Woodward. [Communicated Feb. 2nd, 1832.] Archæologia, vol. xxv. p. 589.
21. An Account of certain Judicial Proceedings at Norwich, at the commencement of the Usurpation, copied from a Manuscript written about 1675, in the possession of Edward Steward, Esq., of Norwich. Communicated by Mr. Samuel Woodward. [April 12th, 1832.] *Ibid.* pp. 591–594.
22. Sketch of an Ancient Sword, found in the Bed of the River Yare, at Thorpe. [Communicated Dec. 12th, 1833.] *Ibid.* pp. 618, 619.
1835.—23. Some Remarks upon the Crag Formation of Norfolk and Suffolk. Phil. Mag. series 3, vol. vii. p. 353.
1836.—24. On the Crag Formation; in answer to Mr. Charlesworth's "Reply." *Ibid.* vol. viii. p. 138.
25. An Account of some Discoveries made in excavating the Foundations of Wymondham Abbey, with a Plan and Description of the Religious Establishment. [Communicated December, 1834.] Archæologia, vol. xxvi. pp. 287–299. [Also Letter on this subject to Editor of "Norwich Mercury," dated 30th December, 1833.]
26. Modern Conglomerate at Cromer. Mag. Nat. Hist. vol. ix. p. 47.
27. Evidence in argument that remains of *Mastodon giganteus* and *Mastodon latidens* have been found in the Tertiary Beds of Norfolk. *Ibid.* p. 151.
1838.—28. Ancient Swords, found near Norwich. [Communicated November 16th, 1837.] Archæologia, vol. xxvii. pp. 435–437.
1842.—29. The Norfolk Topographer's Manual: being a Catalogue of the Books and Engravings hitherto published in relation to the County. The whole revised and augmented by W. C. Ewing. 8vo. London.
1847.—30. The History and Antiquities of Norwich Castle. Edited by his Son [B. B. Woodward]. 4to. London and Norwich.

II.—Essays in Theoretical Geology.

By R. D. Oldham, A.R.S.M., F.G.S.,
of the Geological Survey of India.

3. The Age and Origin of the Himalayas, with Especial Reference to the Rev. O. Fisher's Theory of Mountain Formation.

Introductory.

IT has become one of the truisms of geology that India, like Gaul, is divided into three parts, the Peninsular, the Extra-peninsular, and the Indo-gangetic alluvium.

Of these the first, the Peninsular, has been dry land since the Palæozoic period at least. It consists of a core of highly metamorphosed and contorted gneiss, on which are the remains of a skin of sedimentary rocks of various ages, and a vast expanse of trappean outbursts. Except in the Aravallis, the beds are but slightly disturbed, and the whole area has evidently been in a state of quiescence

throughout the greater part of the period which has elapsed since the commencement of the sedimentary period. The region seems to have undergone but little oscillation of level, and such oscillations as have taken place never brought more than the margins of the area beneath the level of the sea. With the exception of the Aravallis before mentioned, there is no structural mountain-range in the Peninsular area, and such tracts as, from their elevation, deserve the name of mountains, owe their limitations to the action of subaerial denudation.

In contrast with this the Extra-peninsular area, if we except the Upper Tertiary beds at the top of the sequence and the Archæan gneisses at the base, contains few sedimentary rocks which are not of marine origin. Almost everywhere they are intensely disturbed, and the area is essentially one of structural mountain ranges, that is, of ranges whose general direction is closely connected with, and caused by, the disturbance the beds have undergone. Of this area we are at present concerned with the Himalayas, that system of mountains which rises abruptly from the plains of Upper India, range beyond range, to the snow-clad summits forming the highest spots on the surface of the Earth.

In the contour of the two areas there is a vast difference. The surface of the Peninsular area shows rounded outlying and gentle slopes, except where the outcrop of hard or massive beds has led to the formation of scarps; the gradients of the streams are flat, their beds sandy, and seldom do they show signs of active erosion of their channels; in fact, the Peninsular area shows all the features of an ancient land-surface, long exposed to subaerial denudation, in which the streams and hill-slopes have alike gone far towards reaching a condition of equilibrium.

The Himalayas, on the contrary, are a region of deep, steep-sided, valleys and gorges; nearly everywhere the streams and rivers alike are torrents flowing over a bed of coarse boulders, everywhere, with but local exceptions, they are evidently eroding their channels, while the steep slopes and sharp crests of the ridges, no less than the constant landslips and general instability of the soil, betoken a country in which the action of rain and frosts on the hill-sides has not been able to keep pace with the deepening of the stream-beds by erosion.

Equally striking is the contrast in the nature of the boundary of the two areas with the Indo-gangetic alluvium. To the north the Himalayas rise abruptly from slopes of recent gravels at their base, and, though there are irregularities of detail, the boundary as a whole sweeps in a crescent curve from one extremity to the other, while there are no outliers of the Himalayan beds surrounded by alluvium, nor are there any long tongues of the latter running up into the Himalayan area. To the south the rocks slip imperceptibly under the alluvium, so much so that different observers have differed by miles in the boundary they drew between the alluvium and the older rock; the boundary exhibits every variety of irregularity, long tongues of alluvium run up the various river valleys far into

the rock area, and, to crown all, there are outliers innumerable of the peninsular rocks standing up from the alluvial plain.

These last contrasts between the two areas are shown even on a good topographical map; but that now to be mentioned, the most important of all, can only be seen on one that is geologically coloured.

Along its southern boundary the alluvium is in contact with rocks of various ages; but to the north, with the exception of a short distance in Sikkim, a zone of rocks of Tertiary age separates the alluvium on the one hand from the pre-Tertiary rocks of the Himalayas on the other. In a word, the southern boundary is due to the freaks of denudation and alteration of level, while the northern is a structural boundary; and this will be made still more evident when we come to consider in more detail that band of Tertiary deposits which forms the southern margin of the Himalayas, and has so important a bearing on the subject with which this paper deals.

Part I. The Facts.

The Tertiaries of the outer Himalayas present a marked similarity of type along the whole extent of the range, but the sequence is not everywhere equally complete. In the extreme north-west there is a great series of beds, ranging from the marine Nummulitics at the base to the subaerially deposited Pliocene conglomerate sandstones and clays at the summit. They were divided by Mr. Wynne, who examined this country, as follows:[1]—

1. Upper Siwalik, about 4000 feet; brown drab or reddish clays, soft grey sandstones, conglomerates.
2. Lower Siwalik, about 10,000 feet; soft grey sandstones and brown and grey clays, many red clays.
3. Murree beds, average 7500 feet; harder grey sandstones with soft zones, red or purple clays.
4. Nummulitic, upper 800 feet; greenish grey and purple sandstones, grey, olive-brownish, red and variegated clays with masses of gypsum.
5. Nummulitic limestones with shales and coal at base.

The series is said to be parallel and conformable from the pale limestones upwards to the top of the Siwaliks.

The series in the Jamu[2] (Jummoo) hills appears to be practically the same, except that the Nummulitic Limestone is much less developed.

In the Simla region the Tertiaries are divided into two distinct areas, in which the beds are of different ages, though they may slightly overlap each other. The first area forms part of the lower Himalayas and the beds constitute the so-called Sirmur series, divided into

1. The Kasaoli group; grey sandstones, sandy shales, and shales containing plant-remains.
2. The Dagshai group; hard, fine-grained sandstones and red or purple nodular shales, the former prevailing in the upper and the latter in the lower part of the group.

[1] Records Geol. Surv. India, vol. x. p. 112 (1877).
[2] Mem. Geol. Surv. India, vol. xxii. chap. v. (1883).

3. The Subathu group; olive green, grey and red shales and subsidiary bands of sandstone and argillaceous limestone, with a coal-seam and a peculiar ferruginous bed at the base. It contains Nummulites and other marine fossils.

The second area, forming part of the sub-Himalayas, is divided from the Sirmur series by a great fault, and, in many places, by a narrow strip of pre-Tertiary beds; the series may be divided as follows:

1. Upper Siwalik; soft sandstones or sandrock, conglomerates and some clays.
2. Lower Siwalik; soft sandstones or occasionally pebbly sandstones, and clays mostly grey, but sometimes tinged with red, especially in the lower part of the group.
3. Nahan group; firm or hard sandstones interbedded with clays generally nodular and of a bright red colour, which are more abundant in the lower part of the group than in the upper.[1]

The series in the two areas combined appears to be much the same as in the Murree hills. The Nummulitic Limestone is not developed, and the marine deposits are much less in thickness; but there can be no doubt that the Subathu group represents the Nummulitic groups of Mr. Wynne. The Dagshai and Murree groups correspond so closely in mineral character and stratigraphical position that there can be no risk of error in correlating them, while the two upper groups in the north-west are evidently the equivalents of the three groups in the sub-Himalayas of the Simla region and possibly in part of the Kasaoli group of the Sirmur series.

To the east of the Ganges there are a few small outliers of the Subathu group faulted and folded among the pre-Tertiary beds near their southern boundary; but with this exception the only Tertiary beds known here or to the eastwards are confined to the Nahan and Siwalik groups.[2]

Besides these Tertiaries of the Outer Himalayas, beds of the same age are known to exist at several places to the north of the main snowy range; but it is only in Cashmere territory that they have been examined in any detail. In the Upper Indus Valley the Nummulitics may be briefly described as consisting, at the base, of coarse-grained sandstones, arkose beds and conglomerates, considered by Mr. Lydekker to be of glacial origin; they are certainly of littoral origin, and indicate the close proximity of the original limit of deposition. Above these come red, and green and grey shales, of very similar type to those of the Subathu group, interbedded with limestones: while at the top the series consists of a great thickness of beds, mainly volcanic in their origin and basic or ultrabasic in composition.[3]

The coarse-grained beds of littoral origin are confined to the north-eastern boundary of the exposure, whose south-western boundary is marked by great disturbance, and is in effect a faulted one. It seems then that to the north-east the original limit of deposition was not far removed from the present boundary, but

[1] Comp. Medlicott, Mem. Geol. Surv. India, vol. iii. part 2, chaps. i. and iii.; also Manual of Geology of India, vol. ii. chap. xxii.

[2] Oldham, Rec. Geol. Surv. India, vol. xvii. p. 161 (1884); Middlemiss, Mem. Geol. Surv. India, vol. xxiv. part. ii. 1890.

[3] Mem. Geol. Surv. India, vol. xxii. chap. v.

to the south-west there is no indication of the original limit of deposition; and the small outlier in the Singhe La, between Zanskar and the Indus Valley, is described by Mr. La Touche as consisting of a fœtid limestone, resting directly on the Secondary quartzites without the intervention of any beds of a littoral or shallow-water origin.[1] From this it is evident that the land-surface must have been far to the southwards, and it may be that the sea extended over the whole of the Himalayan area between this and the outcrops of the Subathu group, as it certainly must have done over a considerable portion of it.

Having briefly reviewed the geology of the Himalayas so far as is necessary to make what follows intelligible, we must now enter into a detailed consideration of the evidence. It is not, however, intended to give here anything resembling a complete account of the geology of the Himalayas, for such would be impossible in the space available, but merely to notice such points as have a special connection with the age and elevation of the Himalayas.

The first, most important, most palpable and unmistakeable point that stands out is that, at the commencement of the Tertiary period, the Himalayas did not exist as a distinct mountain range, or at least that, if the Himalayan system of disturbance had commenced, it had not extended north-west of a line, drawn transverse to the range, through the debouchure of the Ganges. This is amply proved by the occurrence of marine nummulitics in the heart of the Himalayas, in the Upper Indus Valley and in Zanskar, at heights of 19,000 to 20,000 feet above the level of the sea.

But besides this the nature of the contact between the Nummulitic and pre-Tertiary beds points to the same conclusion. In the Upper Indus Valley the Nummulitics rest directly on an eroded surface of, presumably, Archæan gneiss; in the outer hills, however, they rest on limestones or slates, and Mr. Medlicott has noticed how, both near Subathu and in the Jamu Hills,[2] wherever the boundary is one of original contact, there is no perceptible divergence of dip between the Tertiary and pre-Tertiary formations. The same appears to be the case with the outliers in Garhwal, and this shows that, though the older rocks had been denuded before the Nummulitics were deposited, they had not at that time been seriously disturbed, and that their position was practically one of horizontality.

It is true that, in his recently published memoir, my colleague, Mr. Middlemiss, has shown good reason for believing that, at the commencement of the Tertiary period, the pre-Tertiary beds were not everywhere so slightly disturbed as the contact with the Nummulitics would indicate.[3] But the Himalayan area is a large one, and it would be unnatural to suppose that there had been no disturbance of any part of it before the commencement of the Tertiary period; while the evidence produced by Mr. Middlemiss

[1] Rec. Geol. Surv. India, vol. xxi. p. 161.
[2] Rec. Geol. Surv. Ind. vol. ix. p. 54.
[3] Mem. Geol. Surv. Ind. vol. xxiv. p. 184.

shows that the pre-Tertiary disturbance was transverse, and did not belong to that which has resulted in the elevation of the Himalayas. It may be that in Kumaon and Garhwal this last had already commenced when the Nummulitics were being deposited and only extended to the north-west at a later period; but there is no evidence to show that it could have commenced before the end of the Secondary period; and the early Palæozoic or still earlier date, to which Mr. Middlemiss would seem inclined to refer the first origin of the Himalayas as a mountain range, is, to say the least, extremely improbable.

Besides the stratigraphical evidence of the absence of disturbance, there is everywhere, from the Jamu Hills to the outliers east of the Ganges, a peculiar pisolitic, ferruginous bed, which invariably occurs at the base of the Subathu group. In mineral and chemical character this closely resembles the laterite of the Peninsula and the laterite beds, which occur interbedded with the Nummulitics of Cutch and Sind, and must probably be referred to the same source of origin. The origin of the laterite of the Peninsula is still a vexed question, which has been much complicated by the very loose manner in which the term has been used; but the balance of evidence seems to show that the true laterite is in some way or other connected with the Deccan Traps, and is directly or indirectly the result of an alteration of them or their detritus. If this same source of origin is accepted for the ferruginous bed at the base of the Subathu group, it follows that the present distinction between Peninsular and Extra-peninsular areas had not been established in Eocene times, and, consequently, that the system of disturbance of which it is the result must, at the outside, only have commenced when the Subathu group was being deposited.

In this connection the occurrence of Gondwana rocks of Peninsular type in Sikkim and the Eastern Himalayas is important. Unfortunately nothing is known of the great area of Nepaul, which occupies the middle third of the length of the Himalayas; but Sikkim cannot in any way be regarded as a terminal area, and the occurrence of Peninsular beds of latest Palæozoic or early Secondary age[1] shows that the present limits between the Peninsular and Himalayan areas cannot have been established until the Secondary period at the earliest.

A further insight into the history of the commencement and progress of the elevation of the Himalayas may be derived from a study of the structure of the sub-Himalayan ranges.

In the region west of the Jhelum the structure of the ground does not enable us to decide with certainty at what date the Himalayan system of disturbance invaded that area; but, so far as can be judged, the beds appear to have undergone but little compression till towards the end of the Tertiary period.

In the Jamu Hills we find the typical sub-Himalayan structure

[1] Mallet, Mem. Geol. Surv. India, vol. xi. part i.; see also Godwin-Austen, Journ. Asiatic Soc. Bengal, part ii. vol. xxxviii. p. 151; La Touche, Records Geol. Surv. India, vol. xviii. p. 121.

has commenced, though not so fully developed as further to the south-east. Next to the pre-Tertiary rocks of the Himalayas proper comes a broad zone, principally formed of the Murree group, at the outer margin of which rise some inliers of pre-Tertiary (Carboniferous?) limestone, overlaid by the marine Subathu group, while near the inner boundary, with the pre-Tertiary rocks, there are some outliers of Upper Siwalik clays and conglomerates. The general section from S.W. to N.E. is therefore an ascending one, and both boundaries of this zone are, in effect, great faults with an upthrow on the Himalayan side. Between this zone of Murree beds and the alluvium of the plains there comes a band of Upper Tertiaries, which, on the only published maps, are divided into an inner, older, and an outer, newer zone; but there is no indication of the nature of the boundary.

After leaving the Jamu Hills, the zone of Lower Tertiaries becomes much restricted in width, till we reach the Simla region. Here the Lower Tertiaries, forming the Sirmur series, are distinctly separated from the Upper Tertiaries or Nahan and Siwalik groups. The boundary is a great reversed fault, and along nearly the whole length of it the two divisions are not in contact, but separated by a band of pre-Tertiary slates and limestones. The beds of the Sirmur series have partaken of the intense disturbance of the pre-Tertiary beds, with which they are folded up in the most complicated manner, and the northern boundary is no longer a single well-defined fault, to the north of which there are no outliers. But the most important point to notice is that in the area occupied by the Sirmur series there is no trace of the Upper Tertiary groups, which were either never deposited or have been completely removed by denudation.

Still further to the south-east, the small outliers in Garhwal only exhibit the remains of the Subathu group, no representative of the two Upper groups of the Sirmur series being found.

The explanation of these facts, which has been adopted by every observer of the ground in question, is that the disturbance of the Himalayas gradually advanced from S.E. to N.W., and that the missing upper groups were never deposited over the outliers owing to the elevation resulting from this disturbance. There is ample corroborative evidence to prove the truth of this hypothesis; but the same result is arrived at even if we suppose that the full sequence of deposits was formed everywhere alike, for the condition of the Simla area is such as would result from a greater elevation and denudation of the Jamu area, while the outliers in Garhwal might result from a still further extension of the same processes. But as both elevation and denudation take time, and as the conditions of the three areas with regard to denudation at least are substantially similar, we reach the same conclusion as before, that the elevation, and consequently the denudation of the Garhwal area must have commenced before that of the Simla area, and this again before that of the Jamu Hills.

Before passing on to a consideration of the evidence of the

Siwalik groups, it will be well to briefly examine the nature and distribution of the deposits now being formed along the foot of the Himalayas. Along the outer margin of the hills there is everywhere a zone of gravel and boulder deposits; near the debouchure of the great rivers this consists of well-rounded fragments of crystalline rocks, quartzite, and some limestone; where there are no large rivers, the fragments are less rounded, and consist of the rocks exposed within the drainage-area of the streams flowing down from the hills. The similarity of these gravels to those brought down at the present day, and the fact that their diversity is matched by that of the gravels of the existing streams, leaves no room for doubt that they deposited the gravels even in those districts where they have since cut deep channels through their old deposits.

Outside the zone of boulders and gravel comes a region of sands, of various degrees of fineness, and outside this again the clays and fine silts which form the bulk of the Gangetic alluvium.

It must not be understood that this division into three zones is absolute. Sand and clay are occasionally found close up to the foot of the hills, even near the debouchures of the great rivers, but none the less it truly represents the general disposition of the recent deposits. The width of the zones is not constant, and the boulder and gravel zone in particular expands opposite the debouchures of the great rivers. With all these local variations the main fact remains, that on any line drawn transverse to the boundary of hill and plain, the deposits, omitting minor variations and local exceptions, decrease in coarseness as we pass away from the hills, that the coarse deposits of gravel and boulders are confined to the immediate neighbourhood of the boundary, and that it is only near the debouchure of the principal rivers that these are composed of large and well-rounded fragments of hard crystalline and metamorphic rocks.[1]

Returning now to the Siwalik deposits, we find that the same relation between the composition of the gravels and the existing drainage system which is exhibited by the recent deposits of the northern margin of the plains, has also been noticed by every observer in the conglomerates of Upper Siwalik age.

In the neighbourhood of the Jumna and Ganges rivers we find a great development of conglomerates, composed of well-rounded boulders of crystalline and metamorphic rocks. East of the Ganges, there comes a tract where the watershed is only a few miles removed from the edge of the hills, and coincident with this there is a narrowing of the Siwalik zone, and a cessation of the thick deposits of sandstone and conglomerate, till the Ramganga and Kosi rivers are reached. Here the Siwalik beds again attain a great width and thickness, and there is a large development of conglomerates.[2]

In the country between the Ganges and the Jumna the conglomerates are largely developed and extend for some little distance

[1] Boulder gravels composed of well-rounded blocks of hard rock are also found in the beds of streams draining from the Upper Siwalik conglomerates; but such exceptions are obvious.

[2] Middlemiss, Mem. Geol. Surv. India, vol. xxiv. pt. 2.

west of the Jumna: but further west, in the country south of Nahan, the conglomerates not only decrease in thickness, but change their character. The well-rounded boulders of crystalline rocks cease, and, in their place, we find imperfectly rounded fragments of limestone, slate, and quartzite derived from the Lower Himalayas, mixed with a large proportion of fragments of Lower Tertiary sandstones.

Where the Sutlej passes out through the Siwalik area, there is again a large development of Upper Siwalik conglomerates and the same features of a prevalence of conglomerates near the great rivers, and their absence away from them, continues all the way to the Jhelum.[1]

This peculiarity in the distribution of the Siwalik conglomerates shows that not only are the Siwalik beds of subaerial origin; but that, when they were formed, the Himalayas existed as an elevated region whose main features of hydrography had already been marked out, and further the occurrence of coarse conglomerates, which could only have been deposited in the immediate neighbourhood of the limit of hill and plain, shows that the southern margin of the former must at that time have been approximately the same as the present boundary between the rocks of the Himalayas and of the Siwalik series.

Taking all these considerations into account, the conclusion becomes inevitable that the Siwalik beds were deposited subaerially and under conditions similar to those of the recent deposits along the foot of the Himalayas; that the latter existed as a mountain range, comparable to that now existing, in which the main features of its hydrography had already been marked out; and consequently that the original northerly extension of the Siwaliks cannot have very far overstepped their present northern boundary.

The thickness of these subaerially formed beds varies considerably, but is always great; from ten to twenty thousand feet and perhaps more in places; and as they now, after having been compressed, disturbed and elevated, do not occur at a height of more than a few thousand feet above the sea, it is evident that they must have been deposited in an area of continuous subsidence, which approximately kept pace with the deposition. On the other hand, the Himalayan area, as I shall subsequently show, has been in a state of continuous elevation throughout the Tertiary period, and this elevation has more than kept pace with the denudation of the surface. We have consequently two parallel regions, one of elevation accompanied by denudation; the other of deposition accompanied by subsidence, and we will now investigate the nature of the boundary between them.

Everywhere along the Himalayas the present boundary, between the Upper Tertiary beds and those of pre-Tertiary age, is a gigantic reversed fault. It is one of the most conspicuous structural features of the Himalayas, and, except for the outliers of Lower Tertiary beds in the Simla district and in Garhwal, and the inliers of pre-Tertiary rocks in Jamu, forms an absolute line of demarcation between

[1] Medlicott, Rec. Geol. Surv. India, vol. ix. p. 57.

the Tertiary and pre-Tertiary formations. In Mr. Medlicott's memoir this great fault was called the "main boundary"—a name which has been found so convenient that it has frequently since been used in the publications of the Geological Survey of India, and will be retained here in the sense indicated above.

This main boundary fault is almost everywhere a clean cut fracture, generally reversed, and as a rule the rocks on either side show little or no signs of that crushing which one would expect to have accompanied so great a displacement. As we have seen, it marks, approximately at least, the limit between what was, in Siwalik times, an area of subsidence and an area of elevation, and it is not unreasonable, on this ground alone, to suppose that it was the actual boundary, and formed *pari passu* with the deposition of the beds to the south.

But the main boundary is not the only fault of its kind, though the most remarkable; for, both in the Himalayan and sub-Himalayan areas, there are similar great faults with an upthrow on the Himalayan side, which have been held to mark successive stages in that southerly advance of the margin of the hills, which is sufficiently proved by the elevation of the Siwalik beds, originally deposited in the plains along the foot of the Himalayas.

This supposition derives considerable support from a consideration of the nature of the boundary between the disturbed Upper Siwaliks and the recent deposits of the plains. With a few exceptions where uppermost Siwalik conglomerates dip towards and under the recent gravels, the boundary is a well-defined one, and the undisturbed recent gravels are in contact with disturbed sandstones from which several thousand feet of overlying strata have been removed by denudation. There are no great irregularities of the boundary or deep embayments of the recent deposits, such as would result from a subsidence of the hills and an encroachment of the recent deposits, such, in fact, as are seen on the southern margin of the alluvium. The beds of which the hills are formed are precisely similar in character, and were deposited under circumstances identical with those of the present submontane deposits; and this, taken in conjunction with the outline of the boundary, leads one naturally to the conclusion that the latter is a structural one, and that the hills have slowly and contemporaneously been undergoing elevation and denudation. At the same time the greater bulk of the débris washed down from them has been deposited near their foot, and, to make room for this vast quantity of débris, the latter area must have been slowly subsiding. We have consequently, in close contiguity with each other, an area which has been subject to elevation, and one which has been subject to depression, the boundary between the two being necessarily analogous to those faults with an upthrow to the north which intersect the sub-Himalayan region, and to the great boundary fault which limits it on the north.[1]

[1] This question is more fully treated by my colleague, Mr. Middlemiss, in his recently published memoir, Mem. Geol. Surv. Ind. vol. xxiv. pt. ii.

In all the sections of the sub-Himalayan beds there is a marked and steady increase in coarseness of texture as we ascend the section. This feature is everywhere observable in the sub-Himalayan sections, and even in the Sirmur series of the Simla Hills there is a steady increase in the proportion of sand to shale from the purely argillaceous Subathu group to the chiefly arenaceous Kasaoli group. This gradual upward increase in coarseness of texture on any one section is an inevitable result of the gradual southward extension of the hill area; for by it the region of fine-grained silts is brought within reach of the sand, and, finally, of the shingle deposits. But besides the increase in coarseness of texture on each section, it is an indubitable fact that the texture of the coarsest beds of each group or division increases with its decrease in age, and this appears to me to be due to a gradual increase in the average size of the debris brought down by the Himalayan streams.

I have already shown that in Eocene times the North-West Himalayas did not exist, and that in Siwalik-Pliocene times there was a mountain range whose hydrography agreed with that of the present day in its main features, and that, to judge by the nature of the burden carried by the rivers, this range must have been comparable in elevation and extent to the present Himalayas. During the Tertiary period, then, the Himalayas were in process of elevation, and it is natural to suppose that, during the earlier part of this process, the gradients of the streams and their powers of transportation would be less than at a later period, and that, consequently, no great deposits of coarse gravel could be found. This supposition derives great support from the fact that throughout the great thickness of the Dagshai and Kasaoli groups, and of the Murree group, not a single pebble has been found, while with one very doubtful exception [1] no conglomerates of Nahan age are known.

In the foregoing passages it has been tacitly assumed that elevation has always been accompanied and caused by disturbance of the beds elevated, and such, in the main, is the case. There are, however, recent undisturbed gravels which rise, in the sub-Himalayan region, to heights of 500 feet above the present river-beds and seem to indicate that there has been a certain amount of elevation unaccompanied by disturbance of the horizontality of the beds elevated. So, too, the fossiliferous Pleistocene deposits of Hundes have probably been elevated without disturbance to some extent, though not so much as was supposed by the earlier observers.[2] With these subsidiary exceptions, which do not affect the general principle, it is true that, in the Himalayas, elevation has always been a result of the compression and disturbance of the beds elevated.

[1] Mem. Geol. Survey India, vol. iii. part ii. p. 135.
[2] Lydekker, Rec. Geol. Survey of India, vol. xiv. pp. 178–183 (1881).

(*To be continued.*)

III.—The Motion of Land-ice.

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AMONGST the many useful tables given in Prof. Prestwich's "Geology" is one on the expansion and contraction of ice under variations in temperature (vol. i. pp. 139 and 183). The table in question is abbreviated from one of greater length, which was published in the year 1845 by Carl Brunner von Wattenwyll in the *Annales de Chimie et de Physique*, 3me ser. tome 14, pp. 369-378, under the title of "Expériences sur la densité de la glace à différentes températures." The author of the paper referred to made an extensive series of observations upon the contraction of ice under various temperatures below the freezing-point; and he proved conclusively that, under these circumstances, the contraction of ice exceeds that of all other solid bodies that had (up to the date of the paper) been studied in this connection. Taking the density of pure water at 0° Centigrade as unity, then the contraction in question for a fall of each degree Centigrade is expressed by the decimal figures in the right-hand column of the following table (*op. cit.* p. 378):—

Temperature.	Density of Ice.	Temperature.	Density of Ice.
0° Centigrade.	0·91800	—11 Centigrade.	0·91924
—1	0·91812	—12	0·91935
—2	0·91823	—13	0·91946
—3	0·91834	—14	0·91957
—4	0·91845	—15	0·91968
—5	0·91856	—16	0·91980
—6	0·91868	—17	0·91991
—7	0·91879	—18	0·92002
—8	0·91890	—19	9·92013
—9	0·91901	—20	0·92025
—10	0·91912		

In connexion with this table the author adds that the mean contraction for a fall in temperature of every degree Centigrade is 0·0000375, or $\frac{3}{80}\frac{1}{00}$.

If the density of the ice increases from 0·91800 at the freezing-point to 0·92025 as the temperature falls to —20° Centigrade, then, of course, the density will diminish, or, what is the same thing, the bulk will increase, proportionately, as the temperature of the ice rises.

M. Brunner's testimony does not stand uncorroborated; for Prof. Prestwich adds to his summary of the paper (Geology, vol. i. pp. 139, 140) some important observations by Dr. Rae upon the ice of the Arctic American lakes, which bear upon the same question. These observations prove, beyond the possibility of doubt, that ice does contract greatly under low temperatures; and, also, that as the temperature rises towards zero Centigrade, the ice does undergo a corresponding increase in volume.

Professor Prestwich, in summarizing the results of these observations, points out the importance of their bearing upon theories of glacier motion; but in doing so he takes into account the effects of changes of temperature of ice arising only from what one may term subaerial causes. These causes, diurnal, or seasonal, etc., variations of temperature must, of course, play a very important part; but their effects are most marked at or near the surface, and cannot directly affect the movements of the lower parts of the ice to any appreciable extent.

But differences in temperature of large bodies of land-ice are not by any means necessarily connected with the effects of solar heat, or of other causes acting from the upper surface of the ice downwards. However low the surface temperature of a thick mass of ice may fall, its internal temperature will not everywhere be the same as at the surface. Observation and experiment alike have proved that the cold-waves (those below 0° Centigrade) affect the surface layers most, and that their effects become less and less marked as the cold-waves are propagated further into the ice. Eventually, the cold-waves travel downwards to a zone where they hardly lower the temperature of the ice at all. The position of this zone in relation to the surface varies, of course, with the degree of cold prevailing at the particular place under observation. There is thus within every thick mass of land-ice a zone below which diurnal or seasonal variations of temperature may be said to produce no appreciable effect. Above that zone, when the temperature falls below the freezing-point, contraction takes place. Where the cold is most felt, *i.e.* at the surface, the contraction is greatest, and there the ice snaps, unless the downhill flow of the adjoining ice at a higher level is sufficient to relieve the tension. From the surface such cracks extend downward, gradually diminishing in width as the downward effects of the cold-waves diminish, until they die out altogether and terminate downward in unbroken ice. Water flows into the cracks, freezes, and the expansive force thus exerted helps to thrust forward the ice on the downhill side, or wherever else may happen at that spot to be the direction of least resistance; and in this way the ice is made to flow. A rise of temperature brings about a general expansion of the upper part of the ice, and, consequently, also forces it to flow in the direction of least resistance from this cause as well as from the others.

But a flow of the surface layers of ice—extending downward at the most perhaps not more than a few hundred feet—will hardly satisfy the requirements of those geologists who are familiar with the effects of ice-action in well-glaciated regions. Every field-geologist who has spent many years in, say, North Wales, the North West of England, or in Scotland, must feel that, somehow or other, the bottom of the Ice-sheet must have flowed, and must have moved steadily, and with nearly-uniform directions of movement, long enough to admit of the stone-shod sole of the Ice-sheet scoring deep and wide grooves upon the surfaces of even the toughest of rocks. M. Brunner did not follow up his researches; but his conclusions

should do much to convince even those who are not field-geologists that the lower parts of masses of land-ice really do move forward, and are therefore quite competent to score the rock-surface over which they pass, and to score it to almost any extent.

Let us consider what happened with any of the larger affluents of the Ice-sheet in, say, North West Yorkshire, or in Cumberland and Westmorland. During the Glacial period every one of the valleys in those parts was filled to the brim with masses of ice, which, in most cases, can be shown to have moved outwards from the mountain centres towards the lowlands. The inland and uphill movements, which affected certain parts, were exceptional, and took place only at or near the climax, just before the Ice-sheet began to melt away, and long after most of the glacial erosion had been accomplished. There is reason for believing that for a long period the thickness of the ice in places was not less than two thousand feet. All the rock previously carried seaward by subaerial denudation from those valleys was thus replaced, as it were, by a solid mass of other material,—ice. Doubtless, in those days, as is the case with the smaller glaciers of to-day, the surface layers were slowly impelled downhill and seawards by the alternate expansion and contraction of the ice, aided by the expansive action of water freezing in crevasses, as well, of course, by the pressure of the higher masses of ice behind. All these forces, acting separately or in combination, tend to make the line of swiftest flow coincide with the centre line of the upper layers of each stream.

The tendency to flow most rapidly nearest the surface is, however, counteracted by other causes. Every one seems to have overlooked the fact that when a deep valley is filled by ice, that ice tends to act in much the same way in conducting terrestrial heat outwards towards the surface as if there were rock there in the valley instead of ice. The isogeotherms in such a case, instead of following nearly the contour of the valley as they would do if the ice were absent, would be carried to a higher level, whose exact position would vary with the thickness of the ice and with the surface-temperature for the time being. In other words, the lines of equal subterranean temperature of the rocks forming the sides of the valley would enter the adjoining ice itself, and would connect the isogeotherm of one side of the valley with its corresponding line on the other by a downward curve, which would run through the lower part of the ice, instead of through the rock below upon which it lay.

While the surface-temperature and the terrestrial-temperature were alike in degree, it seems possible that there might be no movement of the ice at all, except that due to the downhill impulse derived from heavier masses at a higher level. Where the surface conditions were such as those described near the commencement of this paper, then the locus of swiftest flow tended to the surface. But when, as must generally have happened during the Glacial period, the surface of the ice was kept in a prolonged state of contraction through extreme cold, the higher temperatures prevailing in the parts of the ice nearer the bottoms of the valleys caused the

ice there to expand more than the colder ice overlying, and therefore to move in the direction of least resistance. That direction of least resistance must, under these circumstances, usually remain near the bottoms of the valleys, and it must tend to be modified (1) by the form of the surface adjoining; (2) by the position of the main feeders of that particular ice-stream; and (3) by the situation of the terminal portions of the glacial stream itself.

Another factor comes in here. The movement of a thick mass of ice under enormous pressure (25 tons per square foot for every thousand feet of thickness of ice) must result in the conversion of part of the force so exerted into heat. This in its turn brings about a still further expansion of the parts of the ice in direct contact with the rock, and thus contributes still further to the erosion that is being accomplished by these means. Indeed, it appears to me more than likely that, when once the movement of the lower strata of the ice is set up, terrestrial radiation on the one hand, and the heat generated by the enormous friction on the other, tend to impel the sole of the ice forward with much more regularity, and with much greater evenness of motion, than can be shown to obtain in any part of the surface of any glacier that has yet been carefully examined.

It appears to me that this view of the causes that determine the flow of land-ice will enable us readily to understand the origin of many phenomena of denudation which northern field-geologists have long agreed to refer to glacial action, although no one has explained satisfactorily how those results were accomplished. Lake basins; the remarkable terraces and scars of Wensleydale, etc.; the corries or coums so characteristic of glaciated districts; the great glacial ruts so well seen near Appleby, for example, or near Edinburgh, can each and all be readily enough accounted for if we extend M. Brunner's observations to their proper conclusion, and assume that the flow of a large mass of land-ice is not limited to its upper parts, but extends also to the bottom layers in contact with the rock.

IV.—Notes on a New Fossil Sponge from the Utica Shale Formation (Ordovician) at Ottawa, Canada.

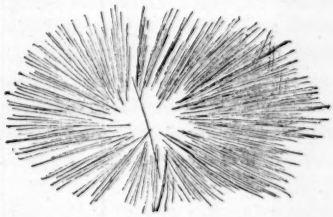
By George Jennings Hinde, Ph.D., F.G.S.

MR. H. M. AMI, F.G.S., of the Geological Survey of Canada, who has devoted special attention to the fauna of the Utica Shale in the neighbourhood of Ottawa, lately sent me for examination several fragments of slabs of this rock containing some peculiar sponge remains, which seem to me to be worthy of notice, although, from their mode of preservation, no decisive determination as to the character of the sponge to which they belong can be arrived at.

The fossils in question appear to the naked eye as so many circular, or, in some instances, fan-shaped, faintly-marked rusty patches on the surface of the black shale, each consisting of delicate

lines or markings radiating from a centre. These patches are so numerous as in places to cover the surface, and their margins overlap each other, so that their individual outlines cannot in all cases be distinguished; further, it can be seen that they are not limited to a single surface layer, for the rock to the thickness of about a millimètre consists of several distinct successive films or layers, each covered with similar rusty patches of radiating lines. Examined with a lens or under a microscope, these lines are seen to be in reality very fine, delicate needle-like spicules radiating horizontally from a centre. The spicules are not all of the same length, so that the outer margin of each patch is uneven, and the general appearance of these circles impressed on the rock-surface calls to mind the nimbus or halo which in old religious books is depicted round the heads of saints.

The circular patches are from 18 to 24 mm. in diameter; the spicules of which they are formed are straight, simple, apparently smooth, and nearly of an even thickness throughout their length, which appears to be from 8 to 10 mm., whilst they are only about ·035 mm. in thickness. In some instances the spicules radiate from the centre of the patch, in others there is a small free central space, and occasionally they are disposed in the shape of a fan. In all cases the spicules form an extremely thin layer. The spicules are for the most part pyritized, in some instances they are reduced to



Stephanella sancta, gen. et sp. nov.; Utica Shale (Ordovician), Ottawa, Canada.

rusty peroxide. This change of the original silica to pyrites and peroxide of iron seems to be of very general occurrence wherever siliceous sponges have been preserved in black bituminous shales; well-known instances are those in the Cambrian shales of St. Davids, South Wales, and those lately described by Sir J. W. Dawson from the black Ordovician shales at Métis, Lower St. Lawrence (Trans. Roy. Soc. Canada, vol. vii. 1889, p. 31).

It may be taken for granted that each of the numerous circular patches in this rock indicates the basal portion of a distinct sponge; but it is hardly likely that it represents the entire skeleton of the organism, and it is insufficient to determine conclusively the nature of the sponge. It has been suggested by Sir J. W. Dawson,[1] who has seen some of the specimens, that they may be the root-spicules of Hexactinellid sponges. As a rule, however, the anchoring-spicules in this group of sponges consist of a more or less compact

[1] Notes on Specimens, Peter Redpath Museum, 1888, p. 59.

bundle of elongated spicules which extend downwards from the base of the sponge and anchor it in the mud, consequently very different from the horizontal radial disposition of the spicules in these specimens. Further, if they were the anchoring appendages of hexactinellid sponges, one would naturally expect to find some traces of cruciform or typical six-rayed spicules characterizing the bodies of these sponges, more particularly as the great regularity in which the free radial spicules forming these circular patches have been preserved in their natural position indicates the absence of currents to remove the body-portions from their bases. But on the slabs I have examined, I do not recognize any distinctive hexactinellid spicules. At the same time it is not altogether impossible that these fossils may be a peculiar modification of the anchoring appendage of hexactinellid sponges, and this view derives some support from the fact that a species of this group, *Cyathospongia reticulata*, Walcott, sp., occurs in this Utica Shale, though Mr. Ami has not yet discovered any specimen of it in the vicinity of Ottawa.

There are however certain recent siliceous Monactinellid and Tetractinellid sponges, inhabiting deep water, which possess basal structures of slender radiating spicules, very similar in character and arrangement to those forming these fossil impressions. Thus in the genus *Radiella*, O. Schmidt[1] (=*Trichostemma*, Sars[2]), there is a basal layer of long straight, styliform or pin-shaped spicules radiating from a centre and forming a definite fringe round the sponge, whilst the spicules of the body of the sponge are smaller and less likely to be preserved as fossil. Again in *Tethya casula*, Carter,[3] there is a well-marked basal fringe of spicules, but in this case the spicules have trifid head-rays and consequently differ in character from those in our fossils. As pointed out by Sars, and more particularly by Ridley and Dendy,[4] the basal fringe of elongated spicules in these sponges serves not so much to anchor the sponge as to support it on the surface of the soft yielding mud of the sea-bottom.

There seems fair ground for supposing that these patches of radiating spicules likewise served as basal supports to sustain the sponges, which lived in dense colonies, on the surface of the ooze. Whether these sponges were hexactinellid or monactinellid must for the present remain an open question; but it may be desirable to give a name to them, and I propose to call them *Stephanella sancta*.[5]

The specimens were collected by Mr. H. M. Ami from the Utica shale, at Ottawa itself, and in the adjoining township of Gloucester.

[1] Spongien Fauna Atlantischen Gebietes (1870), p. 48, pl. 4, fig. 6.
[2] Remarkable Forms of Animal Life (1872), pt. i. p. 62.
[3] Ann. and Mag. Nat. Hist. ser. 4, vol. viii. (1871), p. 99, pl. iv. figs. 1–9.
[4] 'Challenger' Report, Zoology, vol. xx. (1877), p. 216, pl. xliii.
[5] στεφάνη, a wreath, dimin.

V.—Note on the Identity of *Nautilus Neocomiensis*, Sharpe (*non* d'Orbigny) with *Nautilus Deslongchampsianus*, d'Orb.

By Arthur H. Foord, F.G.S.;
and G. C. Crick, Assoc.R.S.M., F.G.S.,
Assistant in the Geological Department, British Museum.

In 1853, in his "Description of the Fossil Remains of Mollusca found in the Chalk of England" (Mon. Pal. Soc.), Sharpe described and figured a specimen under the name of *Nautilus Neocomiensis*, d'Orbigny. He states (*loc. cit.* p. 15), "We have only seen one small specimen from the Grey Chalk, which we can refer to this species; it is from Urchfont near Devizes, in the Collection of Mr. Cunnington, and is 2 inches in its greatest diameter and 1¼ inch in breadth; although a good deal broken, it shows all the peculiar characters of the species. The species is more common in the Lower Greensand of Dorking, Atherfield, Sandgate, etc., where it sometimes reaches above 7 inches in diameter. M. d'Orbigny quotes it as common in the lower beds of the Middle Division of the Neocomian Formation in France."

The specimen referred to is now in the British Museum (No. 88640). It is a natural cast and in its badly preserved state the flexuous ribs appear to be rounded. A close examination of the fossil, however, reveals distinct traces of fine longitudinal lines between the ribs, a character which suggests affinities with *Nautilus Deslongchampsianus*, d'Orbigny. Moreover the remains of the body-chamber, the posterior portion of which Sharpe has represented in his plate v. fig. 3c, show, on either side, at a short distance from the umbilicus, the keel so characteristic of the same species. The area between the keel and the umbilicus is also marked by faint, raised, longitudinal lines. The umbilical portion of the remainder of the specimen is too much broken to show the keel distinctly. The rest of the characters of the specimen, viz., the general form, the form of the sutures and the position of the siphuncle, all agree perfectly with *Nautilus Deslongchampsianus*, and there can be no doubt that the specimen referred by Sharpe to *Nautilus Neocomiensis* is only a small, much-broken and badly-preserved specimen of *Nautilus Deslongchampianus*. The locality and horizon of the fossil also support this conclusion.

Erratum—In Geol. Mag. December, 1890, p. 551, fourth line from top of page, insert *Not* before the paragraph beginning "1853. *Nautilus pseudoelegans*, Sharpe," and ending "figs. 2*a*, 2*b*."

VI.—A Catalogue of British Fossil Vertebrata. Supplement for 1890.

By Arthur Smith Woodward, F.G.S., F.Z.S.,
and Charles Davies Sherborn, F.G.S., F.Z.S.

In the Palæontology of the Vertebrata, so much progress is made in various directions in Britain, that it seems advisable to attempt to bring up to date the record of the subject prepared and published by the writers a year ago. The following list may thus

be regarded as the first supplement to the work in question; and it is hoped, by the courtesy of the Editor, to issue such a list of additions annually in the GEOLOGICAL MAGAZINE.

With regard to general corrections it must be remarked, that the memoir of Mr. J. Ward, forming Vol. X. of the Trans. N. Staffs. Inst. Mining Engin., frequently quoted in connection with Carboniferous fishes, was not issued until February 1890, the publication having been delayed by unforeseen circumstances. Mr. J. Weston, of Fenton, should have been mentioned as the collector of a fine series of fishes from the Staffordshire Coal-measures, which will shortly become the property of the British Museum. In connection with the Carboniferous fishes of the Edinburgh Coal-field, the writers also regret to add that they failed to distinguish between the private and public collections made and extended by Dr. R. H. Traquair, as Keeper of the Natural History Department in the Edinburgh Museum. In this case, however, it is not possible to rectify the error at present, there being no list or catalogue of either of these collections.

A few names applied by Owen to London Clay Teleosteans, in the Cat. Foss. Rept. Pisces Mus. R. Coll. Surgeons, were also overlooked; but most of these refer to species already recorded under the MS. names of Agassiz, and it is thus proposed to defer entering them until the synonymy has been investigated.

PISCES.

Acanthodes Mitchelli, Ag.: remarks and outline-figure by Traquair in Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 481, woodc. 2, under name of *Mesacanthus Mitchelli*.

Acanthodes sulcatus, Ag.: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 392, and Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 481, woodc. 1. Fife and Midlothian.

——— *Wardi*, Eg.: Ward, Trans. N. Staffs. Inst. Min. Engin. vol. x. 1890, p. 157, pl. v. f. 2.

Acrodus minimus, Ag.: Portlock, Rep. Geol. Londonderry, 1843, p. 469, pl. xiv. f. 18 (? 17). Rhætic; N. Ireland.

Acrolepis Hopkinsi, M'Coy: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398 (to include *A. Rankini*).

——— *ortholepis*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398, and Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 492 (olim *Elonichthys ortholepis*).

——— *Rankini* (Ag.): synonym of *A. Hopkinsi*.

——— *semigranulosus* [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398. Calcif. Sandst.; Straiton. [Scales; Edinb. Mus.]

Anodontacanthus attenuatus [n. sp.], J. W. Davis, Proc. Yorks Geol. Soc. vol. xi. (2), 1890, p. 333. [? *Pleuracanthus*]. Carbonif.; Cultra, Co. Down. [Spine; C. Bulla Coll., Belfast.]

Aspidorhynchus crassus [n. sp.], A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 296, pl. iii. f. 11–15 (includes *A. sp.* (1888), *Belonostomus flexuosus*, and *Sauropsis mordax*).

——— sp., A. S. Woodward: v. *A. crassus*.

Asteracanthus Stutchburyi, Ag.: synonym of *A. verrucosus* (E. Wilson, GEOL. MAG. 1890, p. 366). [Type,–Bristol Mus., probably from Purbeck Beds, Swanage.]

——— *verrucosus*, Eg.: includes *A. Stutchburyi*, Ag.

Belonostomus flexuosus, Phillips: = ? maxilla of *Aspidorhynchus crassus*, A. S. W.

——— *leptosteus*, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 296.

Caturus pleiodus [n. sp.], A. S. Woodward (*ex.* Ag.), Proc. Geol. Assoc. vol. xi. (1890), p. 294, pl. iii. f. 10 (genus uncertain).

Centrolepis, Eg.: A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 430.
——— *asper*, Eg. (*ex* Ag.): A. S. Woodward, *ibid.* p. 430, pl. xvi. f. 1.
Ceratodus Phillipsi, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 292, pl. iii. f. 5.
Chirodopsis Geikiei, Traq.: Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 494.
Chirodus crassus [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 400. Carb. Limest.; Abden and Beith. [Scales; Edinb. Mus.]
Chirolepis Trailli, Ag.: recorded from Achanarras, Caithness, by Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 485.
Coccolepis liassica [n. sp.], [-us], A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 435, pl. xvi. f. 2–4. Lower Lias; Lyme Regis. [Fish; Brit. Mus.]
Coccosteus, Ag.: A. v. Koenen, Geol. Mag. 1890, p. 191.
——— *decipiens*, Ag.: Traquair, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 125, pl. x. and Geol. Mag. 1890, p. 235.
——— sp., J. E. Lee, Geol. Mag. 1880, p. 146, pl. v. f. 3. U. Devon.; Chudleigh, S. Devon. [Median dorsal plate; Brit. Mus.]
Cœlacanthus Phillipsi, Ag.: J. W. Davis, Geol. Mag. 1890, p. 159.
——— sp. [n.], J. W. Davis, Proc. Yorks. Geol. Soc. vol. xi. (2), 1890, p. 334. Carbonif.; Cultra, Co. Down. [Bones; C. Bulla Coll., Belfast.]
Cosmolepis, Eg.: synonym of *Oxygnathus*.
——— *Egertoni*, Eg.: v. *Oxygnathus Egertoni*.
Cosmoptychius, Traq.: synonym of *Elonichthys*.
——— *striatus* (Ag.): v. *Elonichthys striatus*.
Ctenodus interruptus, Barkas: A. S. Woodward, Ann. Rep. Yorksh. Phil. Soc. 1889 (1890), p. 37, pl. i. f. 2; R. H. Traquair, Geol. Mag. 1890, p. 249. Form. and loc. are Carb. Limest. and Calcif. Sandst., Fifeshire and Midlothian (not English Coal-Meas.)
——— *Murchisoni*, Ag. MS.: first described by J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. 1890, p. 156. Additional locality is Longton, N. Staffordshire.
——— *caudatus*, Barkas: v. *Sagenodus caudatus*.
——— *corrugatus*, Atthey: v. *Sagenodus corrugatus*.
——— *obliquus*, Atthey: v. *Sagenodus inæqualis*.
——— *obliquus*, var. *quinquecostatus*, Traq.: v. *Sagenodus quinquecostatus*.
——— *obtusus*, Barkas: v. *Sagenodus obtusus*.
——— *octodorsalis*, Barkas: v. *Sagenodus octodorsalis*.
Ctenolepis cyclus, Phillips (*ex* Ag.): A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 301. There is an early fig. of this sp. in C. Prevost, Ann. Sci. Nat. vol. iv. 1825, pl. xviii. f. 21.
Dapedius dorsalis (Ag.): M. Browne, Trans. Leicester Lit. and Phil. Soc. n. s. vol. (1890), p. 196 (includes *Dapedius monilifer*).
——— *monilifer* (Ag.): synonym of *D. dorsalis*.
Diplopterus Agassizi, Traill: Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 484, woodc. 3.
Drydenius [n. g.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 399.
——— *insignis* [n. sp.], R. H. Traquair, *ibid.* Carb. Limest.; Loanhead. [The type species, founded on jaws, etc.; Edinburgh Mus.]
Elonichthys, Giebel: to include *Cosmoptychius*, Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 396.
——— *Dunsi*, Traq.: synonym of *E. nemopterus* (Ag.), Traquair, *ibid.* p. 395. [v. *E. Robisoni*].
——— *intermedius*, Traq.; synonym of *E. nemopterus* (Ag.), Traquair, *ibid.* [v. *E. Robisoni*].
——— *multistriatus* [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 396. Carb. Limest.; Gilmerton and Loanhead [Fragments; Traquair Coll.]
——— *nemopterus* [Ag.]: Traquair, *ibid.* p. 394 (to include *E. Dunsi*, *intermedius*, *ovatus*, *Robisoni*, *striolatus*, *tenuiserratus*). [v. *E. Robisoni*.]
——— *ortholepis*, Traq.: synonym of *Acrolepis ortholepis*.
——— *ovatus*, Traq.: synonym of *E. nemopterus* (Ag.), Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 396. [v. *E. Robisoni*.]
——— *Robisoni* (Hibb.): referred with several other supposed species to *E. nemopterus* by Traquair, as noted above. *Palæoniscus Robisoni*, however,

being described by Agassiz before the so-called *Amblypterus nemopterus*, the specific name originally suggested by Hibbert must be adopted.

Elonichthys striatus (Ag.): Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 396 (olim *Cosmoptychius striatus*).

——— *striolatus* (Ag.): synonym of *E. nemopterus* (Ag.), Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 395. [v. *E. Robisoni*.]

——— *tenuiserratus*, Traq.: synonym of *E. nemopterus* (Ag.), Traquair, *ibid.* [v. *E. Robisoni*].

Eogaleus toliapicus, R. Owen, Cat. Foss. Rept. Pisces Mus. R. Coll. Surgeons, 1854, p. 133. London Clay; Sheppey. [Vertebræ; Mus. R. Coll. Surgeons.]

Eurycormus grandis, A. S. W.: A. S. Woodward, Proc. Geol. Soc. 1890, p. 8, and Geol. Mag. 1890, p. 289, pl. x. f. 1–8.

Eurynotus crenatus, Ag.: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 400 (to include *E. fimbriatus*, Ag.)

——— *fimbriatus*, Ag.: synonym of *E. crenatus*, Ag, Traquair, *ibid.*

——— *microlepidotus* [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 400. Carb. Limest.; Loanhead. [Imperfect fish; Traquair Coll.]

Ganodus, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 290, pl. iii. f. 4.

Ganopristodus, Traq.: synonym of *Uronemus*.

——— *splendens*, Traq.: v. *Uronemus splendens*.

Glyptolepis Flemingii, H. Mitchell and J. Powrie: v. *Holoptychius Flemingi*.

Glyptolepis paucidens (Ag.): Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 483.

Gyrolepis Albertii, Ag.: Portlock, Rep. Geol. Londonderry, 1843, p. 469, pl. xiv. f. 12–14 and f. 11 (*G. tenuistriatus*). Rhætic: N. Ireland.

Gyronchus oblongus, Ag.: v. *Mesodon oblongus*.

Gyrosteus mirabilis, A. S. Woodw.: A. S. Woodward, Naturalist, 1890, p. 101.

Helodus simplex, Ag.: synonym of *Pleuroplax Rankini*.

Holophagus, Eg.: A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 436.

Holoptychius Flemingi, Ag.: includes *Glyptolepis Flemingii*, H. Mitchell, Geologist, 1863, p. 43; J. Powrie, *ibid.*, p. 96.

Ischyodus sp. [n.], A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 290, pl. iii. f. 3. Great Oolite; Northampton. [R. palatine; Jesson Coll.]

Leedsia, A. S. Woodward, Geol. Mag. 1890, p. 292 (substituted for *Leedsichthys*).

——— *problematica*, A. S. Woodward, *ibid.* p. 292, pl. x. f. 9, 10 (olim *Leedsichthys problematicus*).

Lepidotus maximus, Wagner: *Sphærodus neocomiensis* (Ag.), W. Keeping, Foss. Upware, 1883, p. 81, pl. i, f. 4. Neocomian; Cambridgeshire and Bedfordshire.

——— *tuberculatus*, Ag.: = suboperculum of *L. unguiculatus*, Ag. (A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 293).

——— *unguiculatus*, Ag.: A. S. Woodward, *ibid.* p. 292, pl. iii. f. 7, 8. (Includes *L. tuberculatus* and *Pycnodus rudis*).

Leptolepis disjecta [n. sp.], [-us], A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 295, pl. iii, f. 16–19. Stonesfield Slate. [Preop., op., max., and dentary bones; Brit. Mus.]

Macrosemius brevirostris [n. sp.], A. S. Woodward (*ex* Ag.), Proc. Geol. Assoc. vol. xi. (1890), p. 293, pl. iii. f. 9. Stonesfield Slate. [Mandib. ramus; Brit. Mus.]

Megalichthys lævis [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 394. Calcif. Sandst.; Straiton. [Imperfect fishes; Edinb. Mus.]

Mesacanthus, Traq.: genus maintained by Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 481. v. *Acanthodes Mitchelli*.

Mesodon biserialis [n. sp.], A. S. Woodward (*ex* Ag.), Proc. Geol. Assoc. vol. xi. (1890), p. 300, pl. iii. f. 28. Stonesfield Slate. [Mandib. dentition: Brit. Mus.]

——— *Bucklandi* (Ag.): A. S. Woodward, *ibid.* p. 297, pl. iii. f. 20–22: the scales of "*Gyrodus perlatus*" are also figured in the same paper (pl. iii. f. 30, 31). New locality:—Great Oolite of Northampton.

——— *Couloni* (Ag.): *Pycnodus Couloni* (Ag.) W. Keeping, Foss. Upware, 1883, p. 82, pl. i. f. 5. Neocomian; Cambridgeshire and Bedfordshire.

——— *Damoni* [n. sp.], A. S. Woodward, Geol. Mag. 1890, p. 158. This is the *M. sp.*, Woodward and Sherborn, Cat. Brit. Foss. Vert., 1890, p. 121.

——— *Daviesi* [n. sp.], A. S. Woodward, Proc. Zool. Soc. 1890, p. 351, pl. xxviii. f. 5. Purbeck; Swanage. [Fish: Brit. Mus.]

Mesodon ? discoides [n. sp.], A. S. Woodward (*ex* Ag.), Proc. Geol. Assoc. vol. xi. (1890), p. 300, pl. iii. f. 32. Gt. Oolite; Oxford. [Vomer; Brit. Mus.]

——— *latidens*, A. S. W.: misprint for *M. tenuidens*.

——— *oblongus* (Ag.): *Gyronchus (Scaphodus) oblongus*, L. Agassiz, Poiss. Foss. vol. i. (1844), p. xlii. (name only). *Gyronchus oblongus*, E. Wilson, Geol. Mag. 1890, p. 367.

——— *rugulosus* (Ag.): A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 298, pl. iii. f. 23–27. (Includes *M. trigonus*.)

——— sp., Woodward and Sherborn, Cat. Brit. Foss. Vert. 1890, p. 121: v. *M. Damoni*.

——— *tenuidens* [n. sp.], A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 300 (*latidens*, misprint), pl. iii. f. 29. Stonesfield Slate. [R. splenial; Brit. Mus.]

——— *trigonus* (Ag.): synonym of *M. rugulosus*.

Mesolepis rhomba [n. sp.], Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 493. Calcif. Sandst.; Eskdale. [Fish; Edinburgh Mus.]

——— *tuberculata* [n. sp.], Traquair, *ibid.* p. 493. Calcif. Sandst.; Eskdale. [Fish; Edinburgh Mus.]

Mesopoma [n. g.], Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 493 (incompletely defined).

——— *macrocephalum* [n. sp.], Traquair, *ibid.* p. 493.
Rhadinichthys macrocephalus, Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398. Calcif. Sandst.; Pumpherston, Edinburgh. [Fishes; Traquair Coll.]

——— *politum*, Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 493 (olim *Canobius politus*).

——— *pulchellum*, Traquair, *ibid.* p. 493 (olim *Canobius pulchellus*).

Nemacanthus brevis, Phillips: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 289, pl. iii. f. 1.

Nematoptychius gracilis, Traq.: synonym of *N. Greenocki*.

——— *Greenocki*, (Ag.): Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398. (Includes *N. gracilis* and also *Pygopterus elegans*, C. W. Peach, Rep. Brit. Assoc. 1871 (1872), p. 109, name only.)

Oligopleurus vectensis [n. sp.], A. S. Woodward, Proc. Zool. Soc. 1890, p. 346, pl. xxviii, f. 1–4, pl. xxix, f. 1, 2. Purbeck; Swanage. Wealden; I. of Wight. [Head; Brit. Mus.]

Ophiopsis Flesheri (Ag.): A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 293.

Oracanthus Milleri, Ag.: *O. minor*, E. Wilson, Geol. Mag. 1890, p. 368.

Osteolepis microlepidotus, Pand.: Traquair, Geol. Mag. 1888, p. 516, and Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 484.

Oxygnathus, Eg.: A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 431 (includes *Cosmolepis* and *Thrissonotus*).

——— *Egertoni* (Eg.): A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 432 (olim *Cosmolepis Egertoni*).

——— *ornatus*, Eg.: Traquair, Palæoniscidæ (Pal. Soc. 1877), pl. ii. f. 2; A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 432 (includes *Thrissonotus Colei*).

Palæospondylus [n. g.], Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 485.

——— *Gunni* [n. sp.], Traquair, *ibid.* p. 485, woodc. 4. L. Old Red Sandst., Achanarras, Caithness. [The type species, Edinburgh Mus.]

Phaneropleuron, Huxley: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 393.

Phlyctænaspis [n. g.], R. H. Traquair, Geol. Mag. 1890, p. 144. (Olim *Phlyctænius* [preoccupied Zittel, Spongida]).

——— *Anglica*, Traq.: Traquair, *ibid.*, p. 144, (olim *Phlyctænius anglicus*). Includes *Cephalaspis Salweyi*, Lankester (in part), Fishes O.R.S. pt. 1 (Pal. Soc. 1870), pl. viii. f. 2–4.

Phlyctænius, Traq.: preoccupied, v. *Phlyctænaspis*.

Pholidophorus minor, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 293.

Pleuroplax, A. S. Woodw.: J. W. Davis, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 291, pl. xiii.

——— *Rankini*, H. and A.: J. W. Davis, *ibid.* p. 291, pl. xiii. (includes *Helodus simplex*).

Pristacanthus securis, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 290, pl. iii, f. 2.

Psammosteus: The types of *P. granulatus* and *P. vermicularis* are now in the Dublin Mus. Sci. and Art.

Pterichthys Milleri, Ag.: recorded from Achanarras, Caithness, by Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 483. There is also a specimen from this locality in the Worcester Museum.

Ptychodus mammillaris, Ag.: A. S. Woodward, Ann. Rep. Yorks. Phil. Soc. 1889 (1890), p. 39, pl. i. f. 3–14.

——— *polygyrus*, Ag.: A. S. Woodward, *ibid.* p. 40, pl. i. f. 15–20.

Pycnodus Couloni, Ag.: v. *Mesodon Couloni*.

——— *rudis*, Phillips: synonym of *Lepidotus unguiculatus*.

Pygopterus elegans, Peach: v. *Nematoptychius Greenocki*.

Rhadinacanthus, Traq.: genus maintained for *Diplacanthus longispinus*, Ag., by Traquair, Ann Mag. Nat. Hist. [6] vol. vi. 1890, p. 483, but essential part of original definition admitted erroneous and none substituted.

Rhadinichthys carinatus (Ag.): Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 397 (includes typical *R. Geikiei*).

——— *delicatulus*, Traq.: synonym of *R. elegantulus*.

——— *elegantulus*, Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398, and Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 492 (includes *R. delicatulus* and so-called *R. Geikiei* from Eskdale).

——— *Geikiei*, Traq.: synonym of *R. carinatus* and *R. elegantulus*.

——— *lepturus*, Traq.: synonym of *R. ornatissimus*.

——— *macrocephalus*, Traq. [n. sp.]: v. *Mesopoma macrocephalum*.

——— *ornatissimus* (Ag.): Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 397 (includes *R. lepturus*).

Sagenodus, Owen: This genus must be accepted for the so-called *Ctenodus obliquus* and allied species. It is first defined under the name of *Hemictenodus*, R. H. Traquair, Geol. Mag. 1890, p. 251, and is in part equivalent to *Hemictenodus*, O. Jaekel, Sitzungsb Ges. naturf. Freunde, 1890, p. 7.

——— *caudatus*: correct name of *Ctenodus caudatus*.

——— *corrugatus*: ,, ,, ,, ,, *corrugatus*.

——— *inæqualis*, Owen: the correct name of *Ctenodus obliquus*, with synonyms as already quoted in the Catalogue.

——— *obtusus*: correct name of *Ctenodus obtusus*.

——— *octodorsalis*: correct name of *Ctenodus octodorsalis*.

——— *quinquecostatus*, Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 387. *Hemictenodus quinquecostatus*, Traquair, Geol. Mag. 1890, p. 251 (olim *Ctenodus obliquus*, var. *quinquecostatus*).

Saurichthys acuminatus, Ag.: *S. apicalis*, Portlock, Rep. Geol. Londonderry, 1843, p. 470, pl. xiv. f. 19. Rhætic: N. Ireland.

Sauropsis mordax, Ag.: maxilla of *Aspidorhynchus crassus*.

Scaphodus, Ag. MS.: E. Wilson, Geol. Mag. 1890, p. 367; A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 300.

——— *heteromorphus* [n. sp.], A. S. Woodward (*ex* Ag.), p. 300, pl. iii. f. 33, 34.

——— *oblongus*, Ag.: v. *Mesodon oblongus*.

Strepsodus minor [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 393. Calcif. Sandst.; Pitcorthy. [Scales: Edinb. Mus.]

Strobilodus purbeckensis [n. sp.], A. S. Woodward, Proc. Zool. Soc. 1890, p. 350, pl. xxix. f. 4.

Styracopterus, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 492 (undefined).

——— *fulcratus*, R. H. Traquair, *ibid.* p. 492 (olim *Holurus fulcratus*, Traq.) Calciferous Sandstones, Tarras Foot (not Glencartholm).

Tarrasius problematicus, Traq.: R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 494. Locality is Glencartholm (not Tarras Foot, as originally stated).

Thrissonotus, Ag.: synonym of *Oxygnathus*.

——— *Colei*, Ag.: v. *Oxygnathus ornatus*.

Thynnus scaldisiensis [n. sp.], R. Storms, Mém. Soc. Belge Géol. etc. vol. iii. (1889) p. 163, pl. vii. f. 17–22; A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 294. White Crag: Suffolk. [*Caudal vertebræ*; *Brit. Mus.*]

Thynnus thynnus (Linn.): E. T. Newton, Geol. Mag. 1890, p. 264. Forest Bed: E. Runton. [Vert. centrum; Savin Coll.]

Undina (?) *barroviensis* [n. sp.], A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 436, pl. xvi. f. 5. L. Lias.; Barrow. [Fish: Brit. Mus.]

——— (?) sp. A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890) p. 292, pl. iii. f. 6 [also figd. by Prevost, Ann. Sci. Nat. vol. iv. 1825, pl. xviii. f. 20]. Stonesfield Slate. [Jugular and pterygo-quad.: Brit. Mus.]

Uronemus, Ag.: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 393 (includes *Ganopristodus*).

——— *magnus*, Traq.: = tail of *Ctenodus* or *Sagenodus*, Traquair, Geol. Mag. 1890, p. 252.

——— *splendens*, Traquair, Geol. Mag. 1890, p. 252 (olim *Ganopristodus splendens*).

Amphibia.

Anthracosaurus Russelli, Huxley: Lydekker, Cat. Foss. Rept. B.M.[1] pt. iv. 1890, p. 158.

Anthracerpetum crassosteum, Ow.: Lydekker, Cat. Rept. pt. iv. 1890, p. 214.

Erpetocephalus, Huxley: synonym of *Ichthyerpetum*.

——— *rugosus*, Huxl.: v. *Ichthyerpetum Bradleyæ*.

Ichthyerpetum, Huxley: Lydekker, Cat. Rept. pt. iv. 1890, p. 168 (includes *Erpetocephalus*).

——— *Bradleyæ*, Huxl.: Lydekker, *ibid.* p. 169 (includes *Erpetocephalus rugosus*).

Lepidotosaurus Duffi, Hanc. and Howse: Lydekker, Cat. Rept. pt. iv. 1890, p. 214.

Lepterpetum sp. Lydekker, Cat. Rept. pt. iv. 1890, p. 199. Coal Meas.: Jarrow. [Skeleton: Brit. Mus.]

Loxomma Allmani, Huxley: Embleton, Rep. Brit. Assoc. 1889 (1890), p. 580; Lydekker, Cat. Rept. p. iv. 1890, p. 164, fig. 38.

Macromerium Scoticum [n. sp.], R. Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 291, pl. xii. f. 1, and Cat. Rept. pt. iv. 1890, p. 162. Carb. Limest.; Gilmerton. [Mandib. ramus: Brit. Mus.]

Ophiderpetum Brownriggi, Huxley: Lydekker, Cat. Rept. pt. iv. 1890, p. 206.

Pholidogaster piciformis, Huxley: Lydekker, Cat. Rept. pt. iv. 1890, p. 195.

Urocordylus reticulatus, Hanc. and Atth.: synonym of *U. Wandesfordi*.

——— *Wandesfordi*, Huxley: Lydekker, Cat. Rept. pt. iv. 1890, p. 196 (includes *U. reticulatus*).

Reptilia.

Bothriospondylus suffossus, Owen: Lydekker, Cat. Rept. pt. iv. 1890, p. 242.

Calamospondylus Foxi, Lyd.: Lydekker, Cat. Rept. pt. iv. 1890, p. 243, f. 54.

Camptosaurus Leedsi, Lyd.: Lydekker, Cat. Rept. pt. iv. 1890, p. 258, f. 61.

Cardiodon rugulosus, Owen: Lydekker, Cat. Rept. pt. iv. 1890, p. 236. (*Crown of tooth*; *Gt. Oolite, Cirencester.*)

Cimoliosaurus portlandicus (Owen): Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 47, f. 5, and Cat. Rept. pt. iv. 1890, p. 274. (Cerv. vert.; Mid. Purbeck, Isle of Portland: Brit. Mus.)

———*Richardsoni*, R. Lydekker, Cat. Rept. pt. iv. 1890, p. 276, f. 66.

Cœlosaurus, R. Owen, Cat. Rept. Mus. R. Coll. Surg. 1854, p. 15. [Genus founded on a mutilated centrum of a dorsal vertebra washed out of an oolitic stratum and from the drift of West Norfolk: Mus. R. Coll. Surg.]

Cryptodraco eumerus (Seeley); Lydekker, Cat. Rept. pt. iv. 1890, p. 256.

Goniopholis carinata: first described by R. Owen, Cat. Rept. Mus. R. Coll. Surg. 1854, p. 12, and stated to be from the Great Oolite of Cirencester.

Goniopholis minor, Koken: Lydekker, Cat. Rept. pt. iv. 1890, p. 229. Wealden: Isle of Wight. [*Portions of Skeleton; Brit. Mus.*]

Ichthyosaurus communis, Conyb.: Lydekker, Cat. Rept. pt. iv. 1890, p. 270.

——— *Conybearei*, Lyd.: Wilson, Geol. Mag. 1890, p. 365.

——— *intermedius*, Conyb.: Lydekker, Cat. Rept. pt. iv. 1890, p. 271, f. 65.

——— *thyreospondylus*, Owen: Wilson, *ibid.* p. 365; Lydekker, Cat. Rept. pt. iv. 1890, p. 270 (Portland Oolite, I. of Portland: centrum).

[1] Subsequent references to this work are briefly entered "Cat. Rept."

Iguanodon Dawsoni, Lyd. : Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 38, f. 1 B, and Cat. Rept. pt. iv. 1890, p. 259.
——— *fittoni*, Lyd. : Lydekker, *ibid.* pp. 38, 43, f. 1 C, and *ibid.* p. 260.
——— *hollingtoniensis*, Lyd. : Lydekker, *ibid.* p. 40, f. 1 E, 2, and *ibid.* p. 262.
——— cervical vertebra of : Lydekker, *ibid.* p. 44, f. 3.
Megalosaurus Dunkeri, Koken : Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 46, f. 4, and Cat. Rept. pt. iv. 1890, p. 244. Wadhurst Clay; Hastings. [Metatarsus ; Brit. Mus.]
——— *Oweni*, Lyd. : Lydekker, *ibid.* p. 47, and *ibid.* p. 245.
Metriorhynchus Moreli, Desl. : Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 285, f. 1.
——— *superciliosum* (Blainv.) : Lydekker, Cat. Rept. pt. iv. 1890, p. 232.
Ophthalmosaurus icenicus, Seeley : Lydekker, Cat. Rept. pt. iv. 1890, p. 267, f. 62.
——— *Pleydelli* [n. sp.], R. Lydekker, Cat. Rept. pt. iv. 1890, p. 268, f. 63. Kimmeridge Clay : Billingham [Humerus ; Dorset Mus.]
Peloneustes, Lyd. : Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 49.
——— *Evansi* (Seeley) : Lydekker, *ibid.* p. 52 (olim *Pliosaurus Evansi*).
Pelorosaurus Conybearei (Mant.) : Lydekker, Cat. Rept. pt. iv. 1890, p. 240, f. 53.
——— *humerocristatus* (Hulke) : Lydekker, *ibid.* p. 241.
——— *Leedsi* (Hulke) : Lydekker, *ibid.* p. 242.
——— *Manseli* (Hulke) : Lydekker, *ibid.* p. 241.
Plesiosaurus dolichodirus, Conyb. : Lydekker, Cat. Rept. pt. iv. 1890, p. 277.
Pleurocœlus valdensis, Lyd. : Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 182, pl. ix.
Pliosaurus brachydirus, Owen : Lydekker, Cat. Rept. pt. iv. 1890, p. 271. (Teeth; Kimmeridge, I. of Portland. Head of ischium and propodial ; Portland Oolite, I. of Portland.)
——— *Evansi*, Seeley : v. *Peloneustes Evansi*.
——— *ferox*, Sauv. : Lydekker, Cat. Rept. pt. iv. 1890, p. 272.
Rhamphorhynchus jessoni [n. sp.], R. Lydekker, Cat. Rept. pt. iv. 1890, p. 226. and Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 431, f. 1–4. Oxford Clay; St. Ives. [Bones ; Brit. Mus.]
Steneosaurus brevidens (Phill.) : Lydekker, Cat. Rept. pt. iv. 1890, p. 234. New locality is Great Oolite ; Northampton.
——— *Boutilieri*, Desl. : v. *S. robustus*.
——— *robustus*, R. Owen, Cat. Foss. Rept. Mus. R. Coll. Surgeons, 1854, p. 11. M. Oolite ; Oxfordshire. [Skull and mandible ; ? Oxford Mus.] [Includes *S. oxoniensis* and *S. boutilieri*, according to G. A. Boulenger, *in litt.*]
Streptospondylus Meyeri, R. Owen, Cat. Rept. Mus. R. Coll. Surgeons, 1854, p. 16. Wealden ; Brook. [Dorsal vertebræ, probably of *Iguanodon bernissartensis*; Mus. R. Coll. Surgeons.]
Suchodus [n. g.], Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 288.
——— *durobrivensis* [n. sp.], Lydekker, *ibid.* p. 288, f. 2, 3. Oxford Clay; Peterborough. [Mandib. symphysis ; Leeds Coll.] The type species.
Syngonosaurus macrocercus, Seeley : Lydekker, Cat. Rept. pt. iv. 1890, p. 254, f. 60. [Vertebræ ; Cambridge Greensand.]
Teleosaurus brevirostris, R. Owen, was first described in Cat. Rept. Mus. R. Coll. Surgeons, 1854, p. 8, as from "Oolite ; Chipping Norton." [Skull and mandible ; ? Oxford Mus.]
Thecodontosaurus platyodon (Riley and Stutch.) : Lydekker, Cat. Rept. pt. iv. 1890, p. 246. (Two crowns of teeth ; ? Keuper, Somersetshire.)
[Genus non det.] Axis vertebra and intercentrum of Dinosaur : Lydekker, Cat. Rept. pt. iv. 1890, p. 245, f. 55. (See Woodward and Sherborn, Cat. Brit. Foss. Vert. 1890, p. 296.)
"Horn-like Dinosaurian Bone," R. Lydekker, Quart. Journ. Geol. Soc. vol. xlv. (1890) p. 185. fig. [? Ungual phalanx.]
"Ichnites," T. P. Barkas, Rep. Brit. Assoc. 1889 (1890), p. 565. (Carbonif. Sandst. ; Northumberland.)
——— Lydekker, Cat. Rept. pt. iv. 1890, p. 215.

Aves.

Fulica atra, Linn. : A. Milne-Edwards, Oiseaux Foss. vol. ii. 1871, p. 160. Fens; Cambridge.

Haliaetus pelagicus (Pall.): The type is a *tibia*, not *humerus*.

Phalacrocorax carbo (Linn.): A coracoid in Brit. Mus. has been referred to as = *Graculus carbo*? by A. Milne-Edwards, Oiseaux Foss. vol. i. 1868, p. 277, vol. ii. 1871, p. 592.

Lithornis vulturinus, Owen: The type is in Mus. Coll. Surgeons, not in Brit. Mus.

Tetrao urogallus, Linn.: A. Newton and H. Saunders, in Yarrell, Hist. Brit. Birds, ed. 4, 1882–4, vol. iii. p. 47. [Bones; Cave, Teesdale.]

Mammalia.

Ailurus anglicus, Dawk.: Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 451, pl. xviii. f. 9. [Molar from nodule-bed (Red Crag), Boyton; Mus. Pract. Geol.]

Alces latifrons (John.): The type of *Cervus booides* is a portion of skull, with beam; Norwich Mus.

——— *machlis*, Ag.: The type of *A. palmatus*, Ow., is metacarpus, antibrachium and humerus, Brit. Mus.

Bos taurus, var. *longifrons*, Owen: The type of *B. longifrons* is a frontlet and horn-core; Mus. R. Coll. Surgeons. This was first named *Bos brachyceros* by Owen, and subsequently *Bos latifrons* by Wilde. It is also the "Small ox" of Wood; see Woodward and Sherborn, Cat. Brit. Foss. Vert. 1890, p. 322. The type of *Bison minor* is a metatarsal; ? Mus. R. Coll. Surgeons.

——— var. *primigenius* (Boj.): recorded from Crofthead by J. Geikie, Geol. Mag. 1868, p. 393. The type of *Bos giganteus*, Davies, is a cranium; Brit. Mus.

Capra ibex, Linn.: A. Newton, Zool. Ancient Europe, 1862, p. 13, footnote. Pleist.; Fulbourne, Cambridge. [? Horns; Camb. Mus.]

Cervus elaphus, Linn.: The type of *Strongyloceros spelæus*, Ow., is a base of antler, Brit. Mus.

——— *giganteus* (Blum.): The type of *Megaceros hibernicus* is skeleton; Mus. R. Coll. Surgeons. This is also the type of the genus *Megaceros*. In the addenda to Woodward and Sherborn's Catalogue, p. 396, "page 333," the word "tooth" should read "portion of antler."

Dacrytheruim ovinum (Owen): v. *Xiphodon platyceps*.

Didelphys Colchesteri, Owen: There are some notes on these teeth in E. Charlesworth, Mag. Nat. Hist. n. s. vol. iv. app. pp. 44–72.

Felis brevirostris, Croiz. and Job.: Laing, Rep. Brit. Assoc. 1889 (1890), p. 582. Creswell Caves.

Hippopotamus amphibius, Linn.: The type of *H. major*, Ow., was a lower jaw, *olim* Miss Anna Gurney Coll.

Hyracotherium leporinum, Owen: W. H. Flower was the first to identify *Pliolophus vulpiceps*, Ow., with this species. See Cat. Mus. Vert. R. Coll. Surgeons, 1884, p. 380, and Ency. Brit. vol. xv. 1884, p. 428. [R.L.]

Leucippe Oweni, A. Pomel, Cat. Méth. Vert. Foss. 1853, p. 10. A name used for genus and species of English fossil bat: Pomel refers to Geol. Journ. London, without page or other reference.

Lutra dubia (Blainv.): E. T. Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 444, pl. xviii. f. 1. Red Crag: Woodbridge. [R. mandib. ramus; E. C. Moor Coll.]

——— *Reevei* [n. sp.], E. T. Newton, *ibid.* p. 446, pl. xviii. f. 2. Norwich Crag; Bramerton. [Lower sectorial molar; Reeve Coll.]

Machærodus crenatidens [n.sp.] E. Fabrini, Boll. Com. Geol. Ital. vol. xxi. 1890, p. 162. (Refers Backhouse and Lydekker, Quart. Journ. Geol. Soc. vol. xlii. 1886, p. 309, pl. x. to this form.)

Mesoplodon Floris [n. sp.], E. T. Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 448, pl. xviii. f. 7 A-C (olim *M. Floweri*, Flower (*ex* Canham MS.) *non* v. Haast).

——— *Floweri*, Fl.: v. *M. Floris*.

——— *scaphoides* [n. sp.], E. T. Newton, *ibid.* p. 450, pl. xviii. f. 8. Red Crag; Woodbridge. [Rostrum; Mus. Pract. Geol.]

Microtus amphibius (Linn.): Newton, Geol. Mag. 1890, p. 453. [Records mandib. fragment from Ilford in Mus. Pract. Geol. and says others are known from Crayford and Erith.—Pleistocene.]

Microtus ratticeps (Keys. and Blas.): Newton, *ibid.* p. 453, f. 1, 2. [Records remains from Crayford and Erith in Mus. Pract. Geol. and F. C. J. Spurrell Coll.]

Myodes lemmus (Linn.): Newton, Geol. Mag. 1890, p. 455, f. 7, 8. [Recorded from Erith Pleistocene: mandib. ramus and teeth, F. C. J. Spurrell Coll.]

——— *torquatus* (Desm.): Newton, *ibid.* p. 454, f. 3–6. [Recorded from Erith Pleistocene: r. mandib. ramus, F. C. J. Spurrell Coll.]

Neurogymnurus, Filhol. Prof. Rosenberg, of Dorpat, points out that this name, though invariably adopted, is a misprint for *Necrogymnurus*.

Phoca Moori [n. sp.], E. T. Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 446, pl. xviii. f. 3. Red Crag: Woodbridge. [L. humerus; E. C. Moor Coll.]

Phocanella minor, P. J. van Beneden: E. T. Newton, Quart. Journ. Geol. Soc. vol xlvi. 1890, p. 447, pl. xviii. f. 4. Red Crag: Woodbridge. [Humerus; E. C. Moor Coll.]

Platychœrops Richardsoni, Charlesw.: [R. Lydekker] Ann. Rep. Yorks. Phil. Soc. 1889 (1890), p. 35, pl. 1, f. 1.

Trogontherium minus [n. sp.], E. T. Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 447, pl. xviii. f. 5 (? 6). ? Includes incisor from Sizewell Gap, Norwich Crag, in Geol. Soc. Mus. (Owen, Brit. Foss. Mamm. 1846, p. 192). Red Crag; Woodbridge. [R. maxilla; E. C. Moor Coll.] ? Norwich Crag; Suffolk.

Xiphodon platyceps, Flower: "May be *Dacrytherium ovinum*," R. Lydekker, Cat. Foss. Mamm. B.M. pt. ii. 1885, p. 187.

N.B.—General information on the distribution of Pliocene and Pleistocene Fossil Vertebrata will also be found in the following works:—

W. Whitaker, "The Geology of London and of Part of the Thames Valley," 2 vols. 8vo., London (Geol. Survey), 1889.

C. Reid, "The Pliocene Deposits of Britain," 8vo., London (Geol. Survey), 1890. W. and S.

NOTICES OF MEMOIRS.

I.—Prof. Capellini on a Fossil Italian Species of *Tomistoma*.

G. Capellini. Sul Coccodrilliano Garialoide (Tomistoma calaritanus), scoperto nella Collina di Cagliari nel 1868. Mem. Ac. Linc. (4) Vol. VI. 1890, 4 Plates.

Till within the last few years the existing Schlegel's Gharial, of Borneo, was the only known representative of the genus *Tomistoma*, the skull of which is readily distinguished from that of the Gangetic Gharial (*Garialis gangeticus*) by the forward extension of the nasals to join the premaxillæ in the long snout. Within that period fossil remains of this genus have, however, been determined from the Miocene of Malta (*T. champsoides*) and Lower Austria (*T. eggenburgense*), while it has been suggested that Blainville's *Crocodilus macrorhynchus*, from the Cretaceous Pisolite of France, might also be included in the same genus. In the memoir before us the learned Professor of the University of Bologna makes us acquainted with a third species from Italian strata, for which he proposes the name *T. calaritanus*.[1] This species is described upon the evidence of a skull, somewhat imperfect posteriorly, which was obtained in 1868 from beds at

[1] *T. calaritanum* would appear to be more correct.

Cagliari, which are probably of Miocene age. Prof. Capellini first gives us a plate illustrating the specimen in the condition in which it was obtained from the quarry, and then a larger plate showing the skull completely extracted from its matrix. All the characteristic features of the genus *Tomistoma* are displayed in these plates, so that there is no doubt as to the correctness of the generic determination. The general characters are also very similar to those of the Austrian *T. eggenburgense* (which the author considers is rightly included in *Tomistoma*, although originally described as *Gavialosuchus*); but the snout is relatively shorter and thicker, and the supratemporal fossæ are more nearly circular.

The gradually accumulating evidence of the abundance of *Tomistoma* during the Tertiary period in Europe shows conclusively that the solitary existing species of the genus is one of the many instances of the survival in the Oriental region of ancient European types.

We may mention in passing that the author adopts the amended name *Garialis* in place of the ordinary and incorrect *Gavialis*.

R. L.

II.—Dr. Otto Jakel on Perforating Fungi in Fossil Elasmobranch Teeth.

"Gänge von Fadenpilzen (*Mycelites ossifragus*, Roux) in Dentinbildungen." By Otto Jaekel. [Sitzungsb. Ges. naturf. Freunde, 1890, pp. 92–94.]

During the microscopical examination of sections of the fossil rostral teeth of *Pristiophorus*, Dr. Jaekel observed the minute branching tubes of a boring organism. The latter he regards as a fungus already described by W. Roux as infesting bones and teeth. Similar borings are recorded in "*Sphenodus ornati*," *Corax heterodon*, *Acanthias orpiensis*, *Notidanus primigenius*, and a new extinct species of *Trygon*. We would add that similar borings have already been noticed in fish-scales from the English Chalk.

III.—Dr. W. Dames on a Nothosaurian Reptile from the Muschelkalk.

"*Anarosaurus pumilio*, nov. gen., nov. sp." By Prof. W. Dames. [Zeitschr. deutsch. geol. Ges. 1890, pp. 74–85, pl. i.]

The author describes the remains of the head, neck, and abdominal region of a small Nothosaurian, from the Lower or Middle Muschelkalk of Remkersleben, west of Magdeburg. The specimen is preserved in the Royal University Museum, Göttingen, and it is well shown with its counterpart, of the natural size, in the plate accompanying the memoir. At first sight the reptile appears to be a miniature *Nothosaurus*, but it is considered to be generically distinguished by the club-shaped form of its lower side-teeth, and by the total absence of a cleft in the glenoid border of its coracoid. *Anarosaurus* (as the new genus is termed) is also distinguished from *Lariosaurus* by its dentition, and differs from the type species of the latter in the slenderness of its ribs and femur, and in the

relatively greater length of the neck. *Pachypleura* (or *Neusticosaurus*) has no front teeth such as characterize the form now described, and there are differences in the limbs. *Dactylosaurus* is also excluded from comparison both by its short, stout, cervical vertebræ, and by the absence of an epicondylar foramen in the humerus. Dr. Dames' study of the subject leads him to conclude, that all the Triassic *Nothosaurus*-like reptiles may well be comprised within a single family, that of Nothosauridæ; while the remarkable Mesosauridæ ought not to be regarded as very closely related.

A. S. W.

IV.—On the Mexican Meteorites, with especial regard to the supposed occurrence of wide-spread Meteoritic Showers. By L. Fletcher, M.A., F.R.S., with maps of the region. Mineralogical Magazine, Vol. IX. No. 42, pp. 91–180.

IN this most important contribution to Meteoritic Literature, Mr, Fletcher first points out that the "prevalent belief in wide-spread meteoritic showers" is "as regards the desert of Atacama, based on insufficient evidence," and then goes on to make observations, from which it would appear that he includes Mexico in this statement. Mr. Fletcher notes the Meteoritic falls actually observed (only seven in number); the localities in which Meteoritic masses have been found; the distribution in each locality; the transportation of masses; the natural or artificial dispersion of masses belonging to a single type; and the facts which seem to him to prove that many of the masses probably belong to a single fall. Numerous other points are also carefully considered and the history of each known mass is treated in detail, the actual locality being shown on the maps appended. Although dealing with the Meteoritic falls in a limited district, this paper throws a great light on the general subject and will be found most instructive to all those who are interested in cosmical phenomena.

REVIEWS.

I.—Dr. Ristori on Fossil Italian Apes.

Ristori, G. Le Scimmie Fossili Italiane. Boll. Com. Geol. Vol. VII. Nos. 5–8 (1890).

IN this communication the author affords us some important and interesting information as to the affinities of the fossil Ape from the Miocene of Monte Bamboli known as *Oreopithecus bambolii*. This Ape was originally described by Gervais on the evidence of an imperfect lower jaw of an immature individual; and was then regarded as being a true anthropoid. Quite recently, however, Dr. Max Schlosser came to the conclusion that the genus has nothing to do with that group, but was very closely allied to *Cynocephalus*.

Dr. Ristori now describes and figures a number of imperfect jaws, and considers that while there are undoubtedly some signs of affinity with the *Cercopithecidæ*, as represented by *Semnopithecus* and

Cynocephalus, yet there are others of fully equal importance connecting it with the *Simiidæ*, the characters being, indeed, so equally balanced that the author appears to be undecided to which family it should be referred. Among the characters allying *Oreopithecus* to the inferior apes are the great length of the dental series, and the elongation of the last molars—especially those of the lower jaw. On the other hand, anthropoid affinities are displayed in the shortness of the face, the rounding of the chin, and the contour of the molars, in which the tubercles are arranged diagonally, and do not exhibit the complete cross-crests of the *Simiidæ*. The species was of somewhat larger size than a Gibbon; and it appears highly probably that the author is right in considering this interesting form as one of the ancestors of the existing anthropoid Apes.

The remainder of the paper is devoted to the consideration of *Semnopithecus monspessulanus* and *Macacus* (*Inuus*) *florentinus* of the Pliocene of the Val d'Arno. The latter was originally described by Cocchi as the type of a distinct genus, under the name of *Aulaxinuus*; and it appears that Dr. Forsyth Major's *Macacus ausonianus* is merely a synonym of this form.

We are much interested to learn that this memoir is one of a series intended to illustrate the whole of the Mammalian fauna of the Italian Tertiaries, if the necessary funds are supplied by the Government. The importance of such a series cannot be overestimated, not only to the students of Italian palæontology, but likewise to those of other countries—and more especially England. We therefore most earnestly hope that the Italian Government will be induced to afford the supplies necessary to continue this most important work, which we feel sure will be well carried out under the direction of Professor Stoppani. R. L.

II.—Dr. K. A. von Zittel's Handbook of Palæontology.

Handbuch der Palæontologie—Palæozoologie, Band III. Lief. 4. By Karl A. von Zittel. pp. 633–900, woodcut figs. 561–719. (R. Oldenbourg, Munich and Leipzig, 1890.)

THE fourth part of the third volume of this work, relating to Palæozoology, has just been issued, and extends to the end of the section Aves. The index and title-page of vol. iii. are also added, and there is a short list of Corrigenda, chiefly in connexion with the class Pisces. The Order Crocodilia occupies the first fifty pages, and is regarded as comprising the three suborders of Parasuchia, Pseudosuchia, and Eusuchia; the second being founded for the reception of the remarkable Triassic genera *Aetosaurus*, *Typothorax*, and *Dyoplax*, while the third includes both the Eusuchia and Mesosuchia of Huxley's classification. Few of the illustrations are new, but the selection of published figures is such as to render Dr. von Zittel's account the most completely illustrated synopsis of the order that has hitherto appeared. The number of genera with appended queries shows how much scope for investigation still remains for any one able to undertake an extended review of available

materials; and there will doubtless be much difference of opinion upon some of the author's views of synonymy. The difficult task of presenting an impartial and comprehensible *résumé* of the Dinosauria (as they are still termed) is accomplished in Dr. von Zittel's best style. Several pages are devoted to the history of the classification of the order, with an outline of its principal osteological characters; and considerable space is then occupied with a detailed account of each of the principal types. Three subordinal divisions—Sauropoda, Theropoda, and Orthopoda—are adopted, and of the numerous illustrations no less than two-thirds are the fine woodcuts published in the well-known memoirs of Prof. Marsh. In contributions to knowledge of this order, indeed, Europe sinks into insignificance, except as regards the Iguanodontidæ, Compsognathidæ, and Zanclodontidæ. As in the case of the Crocodilia, some of the nomenclature adopted will not meet with general approval, especially in the New World; but Dr. von Zittel has wisely selected for special prominence a series of the most satisfactorily preserved types, recording them under the names they received in the original memoirs, thus enabling the student and general reader to obtain a clear idea of the subject without becoming involved in the perplexities of synonymy, which none but a specialist, with the actual materials before him, can understand. The Pterosauria constitute the last order of Reptiles discussed, and are illustrated by several fine figures of remains from the Bavarian Lithographic Stone. The author's well-known memoir of 1882 forms the basis of much that has scarcely been incorporated in a text-book previously; and the introduction of the graphic restored figure of *Rhamphorhynchus*, originally adorning that memoir, is a new feature in the present "Handbuch."

The preliminary chapter to the class Aves is of the usual concise and complete character; and in the systematic description the three orders of Saururæ, Ratitæ, and Carinatæ are recognized. Owen's original figure of *Archæopteryx* is not dispensed with, as often happens now, to make way for an illustration of the beautiful fossil in Berlin; but both are given, the one made to supplement the other. Hochstetter's restored portrait of *Dinornis* is as effective as the sketch of *Rhamphorhynchus* already mentioned, and forms a well-chosen contrast to the dry bones on the succeeding pages. The genera *Meionornis* and *Palapteryx* are admitted as distinct from *Dinornis*, but the so-called *Euryapteryx* becomes a synonym of the second, as determined by Hutton and Fürbringer. The Odontolcæ are referred to the Ratitæ, and the Odontormæ to the Carinatæ; and the numerous recent families of Carinatæ with extinct representatives are arranged in sixteen suborders, the latest researches of Fürbringer being especially taken into consideration. Most of the genera are simply recorded, but a brief statement of characters or distribution is given in the case of some of the principal types; and the only important omission in the references to literature we notice is Symington Grieve's work on the Great Auk.

The index to the volume, comprising both genera and species,

occupies thirty-four pages of three columns each, and both students and investigators in the Palæontology of the Lower Vertebrates will feel that at last they have some definite and satisfactory basis to work upon. Dr. von Zittel is to be congratulated upon the completion of another part of his laborious undertaking, and the most gratifying reward that the Professor can receive must be the very evident improvement in the respective authors' knowledge of the literature of the subject in recent contributions to the Palæontology of Fishes, Amphibians, and Reptiles. A. S. W.

III.—Dr. Otto Jaekel on the Systematic Position and Fossil Remains of *Pristiophorus*.

"Ueber die systematische Stellung und ueber fossile Reste der Gattung *Pristiophorus*." By Otto Jaekel. [Zeitschr. deutsch. geol. Ges. 1890, pp. 86–120, pls. ii.–v.]

THIS is a valuable contribution to our knowledge of an interesting Selachian family, of which few traces have been met with among fossils. Six-sevenths of the memoir relate to the skeleton of the existing species, comprising observations made in the Berlin and British Museums; and the remaining pages are devoted to a description of the fossil remains regarded by the author as pertaining to the same type. Prof. Carl Hasse has already recorded vertebræ of *Pristiophorus* from the Molasse of Baltringen, Würtemberg; and Dr. Jaekel now describes rostral teeth from the same formation and locality, considered to justify the establishment of a new species, *Pristiophorus suevicus*. The fossils from the Amuri Beds of New Zealand, determined by J. W. Davis to be caudal spines of a new species of *Trygon* (*T. ensifer*), are now shown, from microscopical characters, to be rostral teeth of another extinct form of *Pristiophorus*. The remarkable *Sclerorhynchus*, from the Upper Cretaceous of Mount Lebanon is also discussed and considered to be a subgenus of *Pristiophorus*. As, however, a discovery in the British Museum a year ago (Proc. Zool. Soc. 1889, p. 450) suggested, and probably proved, that the trunk of the Lebanon genus had been erroneously described under the name of *Squatina crassidens*, it may be well that Dr. Jaekel should reconsider the subject. There is a fine example of the so-called *S. crassidens* in the Noetling Collection at Berlin, which will probably be available for study and comparison.

A. S. W.

IV.—Proceedings of the Geologists' Association, Vol. XI. No. 8. November, 1890.

AMONG the many papers in this number, that of Mr. B. B. Woodward, on the Pleistocene (non-marine) Mollusca of the London Basin seems to be the most valuable. It is this kind of contribution that we like to see, this collecting together, and adding to, of all available information on one subject. Indeed in these days of unlimited writing, the author who takes the trouble to sift the wheat from the chaff deserves as much, or even more thanks, than he who adds scrappy notes to the mass. Mr. Woodward has presented to us, in some fifty pages, the results of all researches in the

subject, and further he has crammed his paper with observations and notes of such value, that it must constitute the principal source of reference to future workers. The paper is well illustrated and it is highly creditable to the Association that they have devoted so much space to this, and so assisted the reader and rendered the work of greater service. A list of the Pleistocene (non-marine) Mollusca is appended, with the correct nomenclature, but such great confusion still exists in the question of priority, that no doubt two of the genera will be changed in the addenda to the completed volume.

A full report of the Excursion of the Association to the Italian Volcanoes, by Dr. Johnston Lavis follows, and should be of material service to those who could not avail themselves of Dr. Lavis' personal guidance, on that interesting occasion.

Professor Boulger contributes a paper on *Capulus*, containing the description of a new species, illustrated by a coloured plate. Other papers of great interest by Dr. Wheelton Hind, Major-Gen. McMahon, T. P. Moody, H. W. Monckton, G. F. Monckton (Gold Deposits of Nova Scotia), H. M. Klaassen, and W. J. Lewis Abbott, complete this bulky number, but space does not permit us to notice all these contributions in detail.

V.—Records of the Geological Survey of New South Wales. Vol. II. Part 1, pp. 1–36, with 3 tables, 2 plates and a map. (Sydney, Department of Mines, 1890.)

I. Mr. T. W. Edgeworth David publishes a proposed "Petrological Classification for the Rocks of New South Wales," giving the terms, lettering and signs to be employed by the Survey.

II. Under the name *T. Lonsdalei*. Mr. R. Etheridge, jun., describes a new species of *Tryplasma*, Lonsdale (*Pholidophyllum*, Lindström), from the Upper Silurian of N.S. Wales. The "pores" described by Lonsdale, the existence of which was doubted by Lindström, are explained as impressions of the thorn-like septa in the matrix filling the inter-tabular spaces. In the same paper Mr. Etheridge assigns doubtfully to *Diphyphyllum* a new species, *D. Porteri*, from the Devonian limestones near Tamworth, N.S.W. The specimens show interesting structural features, and suggest the existence of an inner wall.

III. Mr. W. Anderson has some notes of considerable practical value "on the Tertiary Deep Lead at Tumbarumba," an auriferous river-bed covered by lava-flows. The paper is accompanied by a map.

IV. In a paper of anthropological rather than of geological interest Mr. R. Etheridge, jun., describes and figures "The Aboriginal Rock-Carvings at the Head of Bantry Bay, Middle Harbour, Port Jackson," which he thinks "formed a portion of a *Bora*-ground, the spot set apart for the performance of the initiatory mysteries attending the entrance of youths into manhood's estate."

V. is a note on *Dromornis Australis*, Owen, by the same writer.

Possibly the low price of this publication—1*s.* 6*d.*—is held to excuse the misprints that disfigure it: the Government printer should have his attention drawn to these, especially in Article II.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Nov. 12, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.

The President reported that Mr. L. Belinfante had been temporarily appointed by the Council to the Office of Assistant-Secretary.

The following communications were read:

1. "On the Porphyritic Rocks of the Island of Jersey." By Prof. A. De Lapparent, Foreign Correspondent of the Society. (Communicated by the President.)

The author had some years ago described as Permian a series of porphyritic rocks, of which specimens had been sent to him from Jersey. He had since been led to believe that this view of their age, arrived at from what he knew of similar rocks in France, was erroneous, and in a recent visit to the island had satisfied himself that the English observers who had assigned to these rocks a much higher antiquity were in the right. He now found that the igneous rocks in question underlie the Rozel conglomerate, which must be placed at the very base of the Silurian formations. He reserved his detailed statement for a communication to the Geological Society of France; his present object being to do justice to English geologists, whose views he had formerly opposed.

2. "On a New Species of *Trionyx* from the Miocene of Malta, and a Chelonian Scapula from the London Clay." By R. Lydekker, Esq., B.A., F.G.S.

(i.) The anterior portion of a carapace from the Miocene of Malta exhibits a divided neural between the first pair of costals, as in the Indian species of *Trionyx*, and in *Chitra*. The author describes this Maltese fossil, and discusses its relationship to *Trionyx* and *Chitra*, and names it *Trionyx melitensis*.

He notes the interest of finding another Oriental form in the Miocene of the Maltese Islands, which has already yielded a species of *Tomistoma*.

(ii.) A large scapula from the London Clay of Sheppey is referred to *Eosphargis gigas*, and is considered to support Dr. Baur's view as to the intimate affinity between the *Dermochelyidæ* and *Chelonidæ*.

3. "Notes on Specimens collected by W. Gowland, Esq., F.C.S., in the Korea." By Thomas H. Holland, Esq., of the Geological Survey of India, late Berkeley Fellow of the Owens College. (Communicated by Prof. J. W. Judd, F.R.S., F.G.S.)

The southern half of Korea traversed by Mr. Gowland is of a hilly character. The rocks forming the hills are chiefly crystalline schists—gneisses with graphite, garnet, dichroite, and fluor occurring in considerable abundance, and the whole group is probably part of the great Archæan mass of North-east China. The author describes these metamorphic rocks in detail.

Stratified rocks, probably of Carboniferous age, lie unconformably upon the schists in the south-eastern part of the peninsula, and petrographical notes of these are given in the paper. Through the

crystalline schists and stratified rocks various igneous rocks have been erupted as dykes or in large masses. Amongst these the most conspicuous rock is granite. Biotite- and muscovite-granite are most widely distributed, and in places are cut by dykes of eurite and veins of quartz and pegmatite. The more basic class of rocks is represented by diorites, propylites, andesites, basalts, dolerites, and gabbros. Interesting cases of the gradual passage between the so-called intermediate and basic rocks are found, and various stages in the devitrification and decomposition of andesitic lavas represented. These are described in detail by the author, and compared with similar cases in other regions; and full descriptions of the intrusive rocks are furnished.

There are now no active volcanoes; and there is a notable lack of mineral wealth in the southern part of the Korea.

4. "Further Notes on the Statigraphy of the Bagshot Beds of the London Basin (north side)." By the Rev. A. Irving, D.Sc., F.G.S.

1. The author brings forward new evidence from well-sections, clay-pits recently opened, and excavations, confirming the reading of the country between Wellington-College and Wokingham Stations on the S.E. Railway, as put forward by him in 1887 (Q. J. G. S. vol. xliii. and figure 1 of the paper). We have now actual data for the gradients of the clay-beds, and the thinning-out of both the Lower (fluviatile) Sands and of the Middle green-earth series; the latter, when taken into account, bringing the clays in the Wokingham outlier into stratigraphical alignment with the basal clays of the Middle Group. Certain clays at California are also shown to be in alignment with these; and a sketch-section from Ambarrow to Barkham Hill shows the relative gradients of certain horizons to be such as to justify the relegation of the Pebble-bed there to the base of the Upper Sands; while a microscopical examination of the sands above it brings out the lithological identity of these and of the sands capping Farley Hill with the basal beds of the Upper Sands at Wellington College and on Finchampstead Ridges. The accidental occurrence of thin seams of pipe-clay is rejected as a test of horizons, as affording only ambiguous evidence.

2. A similar succession is shown in a section drawn from Wellington College Well through the sand-pit at the brick-yards by Ninemile Ride (base of the Middle Clays exposed), Easthampstead Church Hill (with more recent data), and Bill Hill (Easthampstead), to the S.W. Railway at Bracknell, bringing the higher beds of those two hills into the horizon of the Upper Sands. Further notes are also added to those of the author's 1888 paper (Q.J.G.S. vol. xliv.) on the Ascot Hills, Englefield Green, and Windsor Park, where the transgressive relation of the Bagshot Beds to the London Clay is maintained.

3. In conclusion, the author points out that the new well-sections confirm the trustworthiness of that at Wellington College as a vertical datum-line; he criticises the views of previous writers and maintains that, with the aid of Lieut. Lyons' recently published contour-map, we can now discriminate between the effects of con-

temporaneous and post-Eocene earth-movements in the area; and that the physical history of the Bagshot Beds, which he has himself propounded, is substantiated by the stratigraphical evidence.

II.—Nov. 26, 1890.—A. Geikie, F.R.S., President, in the Chair. —The following communications were read :—

1. "Account of an Experimental Investigation of the Law that Limits the action of Flowing Streams." By R. D. Oldham, Esq., A.R.S.M., F.G.S., Deputy Superintendent of the Geological Survey of India.

The author brings forward evidence derived from experiments in support of the views expressed in a paper submitted to the Society in 1888. His apparatus consisted of a sloping trough, through which various amounts of water containing definite percentages of sand could be sent. The lower end of the trough issued on to a semicircular platform.

In three experiments with the trough at a slope of 1 in 20, and with the same work to be done in each case, the resulting slopes after sand had accumulated in the trough were as follows:—With one part of sand to 42 of water, a slope of 1 in 40; with 1 of sand to 28 of water, 1 in 20; and with 1 of sand to 14 of water, 1 in 13·3. These slopes were obtained when a condition of equilibrium had been maintained so that the water was just able to transport its burden. By increasing the supply of water from 14 : 1 to 42 : 1, the original slope was eventually obtained.

On the fan formed on the horizontal platform variations in the water supply did not produce nearly so marked an effect as in the confined channel, and the slope varied considerably in different directions.

After a time a channel was cut back into the fan, and its sand swept forward and deposited as a secondary fan in front of the first; and as this grew, it cut back into the reach above, and this in turn cut back towards the head of the fans, and sometimes into the trough. In some cases other secondary fans were formed on the margin of the main fan, but the apparatus was not large enough for further formations. The general slope of the fans, both primary and secondary, was ·06, and that of the reach only ·04, while at the head of the reach, where it was cutting back into the face above, there was a gradient of ·08

The general tendency of the experiments supports not only the specific conclusions as to the normal form and behaviour of a river which has attained a state of equilibrium, but to a greater degree the fundamental assumption that a river will adapt its channel to such a slope and form as will enable it to just transport a solid burden cast upon it.

2. "On the Rocks of North Devon." By Henry Hicks, M.D., F.R.S., Sec.G.S.

During a recent visit to North Devon the author obtained evidence which has led him to believe that far too little importance has hitherto been assigned to the results of movements in the Earth's

crust as affecting the succession of the rocks in that area. The supposed continuous upward succession from the rocks on the shore of the Bristol Channel to those in the neighbourhood of Barnstaple, including, according to some authors, no less than ten groups, and classed into three divisions under the names Lower, Middle, and Upper Devonian, is, the author believes, an erroneous interpretation. The beds, he says, have been greatly plicated and faulted, and consequently several times repeated, and instead of being one continuous series, they occur folded in more or less broken troughs. In the Morte Slates, previously considered unfossiliferous, the author found a *Lingula*, and he believes that these slates are the oldest rocks in the area, and formed the floor upon which the Devonian Rocks were deposited unconformably. As the result of movements in the Earth's crust, the Morte Slates have been brought to the surface and thrust over much newer rocks, producing a deceptive appearance of overlying the latter conformably. The Morte Slates mark the dividing line between the two main troughs. On the north side in ascending order are the Hangman (or Lynton), Combe Martin Bay, and Ilfracombe Beds, and on the south side the Pickwell Down, Baggy Point, and Pilton Beds. Those on the south side of the Morte Slates are, the author believes, a repetition of the beds on the north side. The palæontological evidence is not antagonistic to this view, for an analysis of the Brachiopoda, the only group of fossils in the beds on the south side, which hitherto have been systematically examined, shows that of the twenty species mentioned by Mr. Davidson and others as occurring in the Pickwell Down, Baggy Point, and Pilton Beds (the so-called Upper Devonian rocks), no less than thirteen have already been found in the Middle or Lower Devonian rocks on the north side of the Morte Slates. Four others are recognized Middle Devonian species in other areas; and the three remaining are either doubtful species or ones which have a great vertical range. These facts show that the so-called Upper Devonian rocks in this area do not contain a distinguishing fauna of any importance; and the stratigraphical evidence is opposed to the view that they are a series of rocks distinct from those on the north side of the Morte Slates, which have been classed as Middle and Lower Devonian.

III.—December 10, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "On some Water-worn and Pebble-worn Stones taken from the Apron of the Severn Commissioners' Weir erected across the River at Holt Fleet about eight miles above Worcester." By Henry John Marten, Esq., M.Inst.C.E., F.G.S., etc., Engineer to the Severn Commissioners.

The Weir referred to in the paper was built in 1844 of soft red sandstone, and some of the stones composing the apron of the Weir showing signs of decay were removed in 1887. The average quantity of water passing over each square foot of the stones composing the apron has been estimated at about 2000 gallons per minute. A

large proportion of the stones had been drilled through and through by the action of the current upon small pebbles lodged in hollows or between the joints of the stone; and the author estimates that as a result of 43 years of erosion, six of the stones of the apron, which may be taken as a sample, had lost the following amounts respectively:—45, 60, 48, 50, 37, and 58 per cent.

2. "On the Physical Geology of Tennessee and adjoining Districts in the United States of America." By Prof. Edward Hull, M.A., LL.D., F.R.S., F.G.S., late Director of the Geological Survey of Ireland.

The area described in the paper is occupied by the Unaka or Blue Ridge, which may be regarded as one of the parallel ridges of the Alleghanies, and the prolongation of Prof. J. D. Dana's "Archæan Protaxis." It runs in a general south-westerly direction, and attains an elevation of 6760 feet. At its base, and to the north-west of it, is the Valley of East Tennessee, about 40 miles wide, and furrowed by north-east and south-west ridges and depressions, parallel to the strike of the Cambrian and Silurian beds. Through this runs the Tennessee River, which, instead of running south to the Gulf of Mexico, turns to the north-west, some distance below Chattanooga, and cuts through the Cumberland table-land, a prolongation of the Appalachian mountains, and flows into the Ohio River.

The Cumberland table-land has an average height of 2000 feet above the sea, and 1350 feet above the Tennessee River at Chattanooga. It consists of a synclinal of Carboniferous rocks resting conformably upon the Devonian beds, and is bounded along the East Tennessee Valley by a curved escarpment; a similar though more indented escarpment forming its north-western margin, and separating it from the Silurian plain of Nashville. The table-land is about 40 miles wide, and is intersected by the valley of the Sequachee River, running in a north-easterly direction along a subsidiary anticline from near Jasper for a distance of sixty miles.

From the base of the Cambrian beds, the whole Lower and Upper Palæozoic formations succeed each other in apparently conformable sequence, except at the junction of the Upper and Lower Silurian series, where a probable discordance occurs. The prolonged period of subsidence and deposition at length gave way to elevation; acting with the greatest effect along the Alleghanies. Under these circumstances, denudation proceeded most rapidly along the tract bordering the Protaxis, whilst the synclines were protected from erosion to a greater degree; and as the elevatory movement was more rapid along the Unaka range, the flow of the streams was generally westward. At a later period the Cumberland plateau began to be formed by backward erosion of the strata in the direction of the dip; so that it owes its development to the erosion of the Tennessee and Clinch Rivers on the one hand, and to the Cumberland River on the other. Where the Tennessee River flows in a north-westerly direction through the Cumberland plateau, the divide between it and the Gulf of Mexico is only 280 feet above the river-bed, whilst the table-land is 1400–1500 feet above. The author

infers, therefore, that when the river began to erode its channel, the plateau was relatively lower than the tract to the south of the present course of the stream, but that by denudation the relations have been reversed, whilst the river has never left its originally selected course.

The author compares the state of things with that which must have occurred in the case of the northerly rivers running from the centre of the Wealden axis; but mentions that Prof. Safford and Mr. J. Leslie account for the Cumberland plateau by faulting, though he thinks that the well-defined escarpment along the valley of East Tennessee seems to show that this cause is insufficient.

In conclusion, he believes that the denudation was accelerated during the pluvial or "Champlain" period, and calls attention to the "Columbia formation" on the east side of the Alleghanies, and to the deposit of red loam by which the surface of the country of the valleys of the Tennessee and Sequachee is overspread, and which is probably referable to a similar stage.

3. "On certain Ornithosaurian and Dinosaurian Remains." By R. Lydekker, Esq., B.A., F.G.S.

The author is indebted to Professor O. C. Marsh for the correct determination of the bones described in the paper.

1. *Ornithosaurian Quadrates.*—The reptilian bones in the British Museum, Nos. 43034, 44183, and 41179, are Ornithosaurian quadrates. The two latter belonged to the right side of the skull. The distal extremity of each forms a deeply grooved oblique trochlea, above which is a nearly quadrangular shaft. To the inner side of this shaft is attached, by suture, a flattened plate of bone, concave internally, and convex externally, representing part of the pterygoid; so that the relation of the quadrate to the pterygoid in the *Ornithosauria* is the same as in the *Rhynchocephalia.*

The smaller quadrate would agree approximately in relative size with the so-called *Pterodactylus Manseli*, Owen, and the larger more nearly with the so-called *Pt. suprajurensis*, Sauvage, both of which may be provisionally referred to *Rhamphorhynchus.*

2. *Tibia of Cœluroid Dinosaur.*—The author would provisionally refer the right tibia of a small Dinosaur from the Wealden of the Isle of Wight, which had been incorrectly referred to *Hypsilophodon*, to the species originally described, from an examination of two vertebræ, as *Calamospondylus Foxi*, but which he would now name *Calamosaurus Foxi.* It presents striking avian affinities.

CORRESPONDENCE.

PROF. BONNEY AND GENERAL McMAHON ON THE GEOLOGY OF THE LIZARD DISTRICT.

Sir,—In your last issue, Prof. Bonney in his characteristic style refers to my late work in this district. He, however, at once, falls into error as to the number of my communications to the Magazine, there being five, not four as stated by him. The one he overlooks

being that "On the Schists of the Lizard District," April, 1890, perhaps the one he likes least.

As to the points in his letter under his figures 1, 2, 3 and 4, I have no doubt but that Prof. Bonney will in good time demonstrate these assertions; but in the meanwhile they are only assertions. I will freely and gladly admit the errors, both in my observations and inductions, when proofs are forthcoming. I was much amused by General McMahon's letter. I am well aware (perhaps before the General was) of the apparent sequence of the various rocks laid down by the masterly mind of De la Beche, and also (perhaps) I have seen more of the true dykes in the Lizard District than has fallen under the observations of General McMahon. There are dykes, however, that I regard as of contemporaneous or segregation origin.

Independent of the sequence of the rocks referred to, I think them the product of eruptions of one geological period, that intermittent action is noticeable, and that there is a decided passage of the main masses into each other, and that the same magma, cooling under different conditions, has given rise to many varieties of rock. My communications were intended to lead up to this point.

As to my theory of the origin of the "banded structure," let it with the others "sink or swim." I care not which survives.

As to the close of General McMahon's letter, I much regret having to say, that I think it is quite uncalled for.

TORQUAY, 9TH *December*, 1890. ALEXR. SOMERVAIL.

REPORT OF THE INTERNATIONAL GEOLOGICAL CONGRESS.

SIR,—I am periodically asked by friends who joined the last Geological Congress how it is that the promised report to which each member was said to be entitled has not yet appeared, although some of us paid an additional subscription to expedite its production.

Ought not the eminent geologists whose names appeared on the circular inviting support to that Meeting to be asked to furnish some explanation for this unaccountable delay? (B. V)².

ON DYNAMO-METAMORPHISM.

SIR,—I certainly had no thought of "rolling back the development of chemical theory a few decades at least," when I wrote of energy taking "the molecular forms of heat and chemical action." Dr. Irving in his criticism of this expression leaves out my reference to heat. I conclude therefore that he has no objection to that part of the statement. As to the assertion that part of the energy, which previously existed in the molar form, was converted into the "molecular form of chemical action," I was unable to know whether Dr. Irving's stricture expressed the generally received views upon the subject, owing to my imperfect acquaintance with chemistry. I have, therefore, consulted the highest authority on such questions to whom I could apply and on whose opinion I can place reliance. With respect to Dr. Irving's apparently general statement, that "chemical combination must generate heat," he replies, that, "when

carbon is heated in carbonic acid gas, C O is formed with a disappearance of heat; and, when nitrogen and oxygen are sufficiently heated together, an oxide of nitrogen is formed with a disappearance of heat; and, that in these cases the heat which has disappeared has become chemical energy in the molecules of C O or N O. Whether it be *atomic* energy or not is not at present known, but as the molecule includes the atoms, it is certainly "molecular" as distinguished from ordinary mechanical, or molar energy. Since many chemical changes, which only take place at very high temperatures, appear to be attended with a disappearance of heat, it is at least not improbable that some of the changes, by which minerals are formed in the interior of the earth, may also be attended with a storage of energy."

"Perhaps Dr. Irving takes exception to the supposition that mechanical energy may be directly transformed into chemical energy. If so, you may reply that the known effects of pressure upon chemical changes, when those changes are attended by a change of volume, afford support to the supposition. Recent observations on the influence of surface tension on chemical change by Liebreich, J. J. Thomson, and others, lead in the same direction, so that it cannot be said that the supposition is unreasonable, even in the light of recent advances in physical chemistry."

Finally I am told that the assertion that "chemical combination must generate heat" is certainly incorrect, and that the examples CO and NO to the contrary are "only two out of an immense number."

HARLTON, CAMBRIDGE, 13 *Dec.* O. FISHER.

DYNAMOMETAMORPHISM.

SIR,—I must apologize to Dr. Irving for having overlooked the observations to which he refers. Unfortunately I had not read the work in question at the time when I wrote my letter.

As regards the main subject of his letter in your December number, I would offer only a few words. In assuming that the whole of the work done in the compression, deformation, and friction of rock-masses passes into heat, Dr. Irving misses the idea which underlay the whole of my remarks, and was more explicitly stated in Mr. Fisher's article. The *direct* correlation of mechanical and chemical energy was, I believe, first mooted by Dr. Sorby in 1863; but the practical verification of it rests on such experiments as those of Cailletet, Pfaff, and Spring. To take an example: Spring subjects a mixture of sulphur and copper filings to a pressure of 5000 atmospheres, and finds it converted into crystallised copper sulphide. The operation is conducted slowly, and the temperature of the apparatus kept constant. In other words, so much of the mechanically-developed energy as takes the form of heat is carefully removed; but chemical combination still takes place. It follows that the energy absorbed in this combination comes directly from the mechanical work done, without the intervention of heat.

ST. JOHN'S COLLEGE, CAMBRIDGE. ALFRED HARKER.